

# **SOCIAL TOOLS FOR EVERYDAY ADOLESCENT HEALTH**

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# **SOCIAL TOOLS FOR EVERYDAY ADOLESCENT HEALTH**

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*To my husband, Robert Bolyard*

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## SUMMARY

In order to support people's everyday health and wellness goals, health practitioners and organizations are embracing a more holistic approach to medicine—supporting patients both as individuals and members of their families and communities, and meeting people where they are: at home, work, and school. This 'everyday' approach to health has been enabled by new technologies, both dedicated—devices and services designed specifically for health sensing and feedback—and multipurpose—such as smartphones and broadband-connected computers. Our physical relationship with computing has also become more intimate, and personal health devices can now track and report an unprecedented amount of information about our bodies, following their users around to an extent no doctor, coach or dietitian ever could.

But we still have much to learn about how pervasive health devices can actually help promote the adoption of new health practices in daily life. Once they're 'in the wild,' such devices interact with their users, but also the physical, social and political worlds in which those users live. These external factors—such as the walkability of a person's neighborhood or the social acceptability of exercise and fitness activities—play a significant role in people's ability to change their health behaviors and sustain that change. Specifically, *social theories of behavior change* suggest that peer support may be critical in changing health attitudes and behaviors. These theories—Social Support Theory, Social Cognitive Theory and Social Comparison Theory among them—offer both larger frameworks for understanding the social influences of health behavior change and specific mechanisms by which that behavior change could be supported through interpersonal interaction. However, we are

only beginning to understand the role that pervasive health technologies can play in supporting and mediating social interaction to motivate people's exploration and adoption of healthy behaviors.

In this dissertation I seek to better understand how social computing technologies can help people *help each other* live healthier lives. I ground my research in a participant-led investigation of a specific population and condition: adolescents and obesity prevention. I want to understand how social behavior change theories from psychology and sociology apply to pervasive social health technology. Which mechanisms work and why? How does introducing a pervasive social health system into a community affect individuals' behaviors and attitudes towards their health? Finally, I want to contribute back to those theories, testing their effectiveness in novel technologically mediated situations.

Adolescent obesity is a particularly salient domain in which to study these issues. In the last 30 years, adolescent obesity rates in the US alone have tripled, and although they have leveled off in recent years they remain elevated compared to historical norms. Habits formed during adolescence can have lifelong effects, and health promotion research shows that even the simple act of walking more each day has lasting benefits. Everyday health and fitness research in HCI has generally focused on social comparison and "gamified" competition. This is especially true in studies focused on adolescents and teens. However, both theory from social psychology and evidence from the health promotion community suggest that these direct egocentric models of behavior change may be limited in scope: they may only work for certain kinds of people, and their effects may be short-lived once the competitive framework is removed. I see an opportunity for a different approach: social tools for everyday adolescent health. These systems, embedded in existing school and community practices, can leverage scalable, non-competitive social interaction to catalyze positive perceptions of physical activity and social support for fitness, while remaining grounded in the local environment.

Over the last several years I have completed a series of field engagements with middle school students in the Atlanta area. I have focused on students in a majority-minority low-income community in the Atlanta metropolitan area facing above-average adult obesity levels, and I have involved the students as informants throughout the design process. In this dissertation, I report findings based on a series of participatory design-based formative explorations; the iterative design of a pedometer-based pervasive health system to test these theories in practice; and the deployment of this system—StepStream—in three configurations: a prototype deployment, a ‘self-tracking’ deployment, and a ‘social’ deployment.

In this dissertation, I test the following thesis: *A school-based social fitness approach to everyday adolescent health can positively influence offline health behaviors in real-world settings. Furthermore, a noncompetitive social fitness system can perform comparably in attitude and behavior change to more competitive or direct-comparison systems, especially for those most in need of behavior change.* I make the following contributions: (1) The identification of tensions and priorities for the design of everyday health systems for adolescents; (2) A design overview of StepStream, a social tool for everyday adolescent health; (3) A description of StepStream’s deployment from a socio-technical perspective, describing the intervention as a school-based pervasive computing system; (4) An empirical study of a noncompetitive awareness system for physical activity; (5) A comparison of this system in two configurations in two different middle schools; (6) An analysis of observational learning and collective efficacy in a pervasive health system.

# CHAPTER I

## INTRODUCTION

Health informatics technology is finally “exiting the cleanroom” [15], expanding beyond the clinic and becoming embedded in people’s daily lives. In order to support people’s everyday health and wellness goals, health practitioners and organizations are embracing a more holistic approach to medicine—supporting patients both as individuals and members of their families and communities, and meeting people where they are: at home, work, and school. This ‘everyday’ approach to health has been enabled by new technologies, both dedicated—devices and services designed specifically for health sensing and feedback—and multipurpose—such as smartphones and broadband-connected computers.

Our physical relationship with computing has also become more intimate. Ubiquitous computing devices are becoming increasingly networked, and social applications are extending their reach into the ‘offline’ world. In the last several years, ubicomp devices and services have become robust enough to withstand life outside the lab. These advances have resulted in the rapid proliferation of wireless health and fitness products, from pedometers, scales and wristbands to quantified-self forks to continuous glucose monitoring contact lenses. Personal health devices can now track and report an unprecedented amount of information about our bodies, following their users around to an extent no doctor, coach or dietitian ever could.

But we still have much to learn about how pervasive health devices can actually help promote the adoption of new health practices in daily life. Once they’re ‘in the wild,’ such devices interact with their users, but also the physical, social and political worlds in which those users live. These external factors—such as the walkability of a person’s neighborhood

or the social acceptability of exercise and fitness activities—play a significant role in people’s ability to change their health behaviors and sustain that change. Specifically, *social theories of behavior change* suggest that peer support may be critical in changing health attitudes and behaviors. These theories—Social Support Theory, Social Cognitive Theory and Social Comparison Theory among them—offer both larger frameworks for understanding the social influences of health behavior change and specific mechanisms by which that behavior change could be supported through interpersonal interaction. However, we are only beginning to understand the role that pervasive health technologies can play in supporting and mediating social interaction to motivate people’s exploration and adoption of healthy behaviors.

In this dissertation I seek to better understand how social computing technologies can help people *help each other* live healthier lives. I ground my research in a participant-led investigation of a specific population and condition: adolescents and obesity prevention. I want to understand how social behavior change theories from psychology and sociology apply to pervasive social health technology. Which mechanisms work and why? How does introducing a pervasive social health system into a community affect individuals’ behaviors and attitudes towards their health? Finally, I want to contribute back to those theories, testing their effectiveness in novel technologically mediated situations.

Adolescent obesity is a particularly salient domain in which to study these issues. In the last 30 years, adolescent obesity rates in the US alone have tripled [14], and although they have leveled off in recent years they remain elevated compared to historical norms. Habits formed during adolescence can have lifelong effects: adolescent obesity is the single biggest predictor of obesity in adulthood [14]. Additionally, health promotion research shows that even the simple act of walking more each day has lasting benefits [27]. Additionally, lower physical activity levels are a key correlate of obesity in adolescence [80]. Social psychology research shows that adolescents are more receptive to social mechanisms of behavior change [3, 91].



Despite the wide range of social behavior change theories available, everyday health and fitness research in HCI has generally focused on social comparison and “gamified” competition. This is especially true in studies focused on adolescents and teens: youth-focused fitness systems in HCI have generally been designed to provide competitive or social comparison-based motivation. These experiences are typically facilitated within a small group of close friends or a coach-led competition. However, these approaches have some limitations. Competition-based systems may motivate only top performers, providing little motivational support for other participants [30]. Participants in school-based fitness deployments that employ rewards and direct competition often return to pre-deployment activity levels after the removal of the deployment system [30]. Systems that leverage strong ties for close friends may not be able to reach a large number of students and are limited to cliques where there is at least nascent interest in improved physical fitness.

However, both theory from social psychology and evidence from the health promotion community suggest that these direct egocentric models of behavior change may be limited in scope: they may only work for certain kinds of people, and their effects may be short-lived once the competitive framework is removed. I see an opportunity for a different approach: social tools for everyday adolescent health. These systems, embedded in existing school and community practices, can leverage scalable, non-competitive social interaction to catalyze positive perceptions of physical activity and social support for fitness, while remaining grounded in the local environment. Evidence from previous school-based fitness systems and social behavior change theory gives reason to expect a school-based social approach might prove valuable, particularly the potential of non-competitive social support to enhance collective efficacy and observational learning.

To test these theories in an HCI context, and to gain new insights about the role and capabilities of technology in shaping a school-based social fitness system, over the last several years I have completed a series of field engagements with middle school students

in the Atlanta area. I have focused on students in a majority-minority low-income community in the Atlanta metropolitan area facing above-average adult obesity levels, and I have involved the students as informants throughout the design process. In this dissertation, I report findings based on:

- A series of participatory design-based formative explorations
- The iterative design of a pedometer-based pervasive health system to test these theories in practice
- The deployment of this system—StepStream—in three configurations: a prototype deployment, a ‘self-tracking’ deployment, and a ‘social’ deployment

## ***1.1 Research Questions***

In this dissertation, I test the following thesis: *A school-based social fitness approach to everyday adolescent health can positively influence offline health behaviors in real-world settings. Furthermore, a noncompetitive social fitness system can perform comparably in attitude and behavior change to more competitive or direct-comparison systems, especially for those most in need of behavior change.*

While investigating this thesis, I also address the following broader research questions:

**RQ1: What are adolescents’ priorities with respect to pervasive social fitness applications, and how do these factors influence the design of social tools for everyday adolescent health?** Researchers and designers of adolescent-focused pervasive health systems have many potential theories and existing best practices at their disposal. In my formative work, I conducted a series of participatory design studies to identify which ones matter—both for pervasive social health games and within the cultural context of the Atlanta-area community I studied over the course of the dissertation. I describe these studies in detail in Chapter 4. I found design implications in four key areas: social presence, gender effects, incentives and competition [56]. I describe how these themes manifested

in students' designs and why they were particularly important to my participants. I subsequently use these findings in the design of my system, StepStream.

**RQ2: How can technology be designed to support social awareness and encouragement in an adolescent-focused fitness system?** I answered this question with a combination of my formative work and the design work leading up to my primary deployments of StepStream. My design reflects priorities taken from previous persuasive and pervasive health designs as well as priorities unique to my approach, such as encouraging a primary stream of chat while obfuscating raw step-counts (described in detail in Chapter 5). I also answer this research question more broadly by considering the design of the socio-technical system for this intervention as a core design challenge.

**RQ3: How do we understand potential advantages & disadvantages of noncompetitive awareness systems for adolescent fitness?** I found that my system, StepStream, improved participants' sense of social support for fitness, and increased both their enjoyment and sense of expertise. The students with the lowest initial physical activity levels significantly improved their daily step-counts. These changes were comparable to those seen in more directly competitive systems. I discuss this finding in more detail in Chapters 6 and 7.

Through my dissertation research, I make the following contributions:

1. The identification of tensions and priorities for the design of everyday health systems for adolescents
2. A design overview of StepStream, a social tool for everyday adolescent health
3. A description of StepStream's deployment from a socio-technical perspective, describing the intervention as a school-based pervasive computing system
4. An empirical study of a noncompetitive awareness system for physical activity
5. A comparison of this system in two configurations in two different middle schools

6. An analysis of observational learning and collective efficacy in a pervasive health system

## ***1.2 Overview of Dissertation***

This dissertation is organized as follows: Chapter 2 describes related work and the theoretical foundations of my research. I describe related systems and studies, with a focus on previous pervasive health deployments for youth. I also introduce and contextualize the theories relevant to my work, including Social Cognitive Theory, Social Comparison Theory, Social Support Theory and various mechanisms related to those theories, such as collective efficacy and observational learning.

In Chapters 3 and 4, I describe the formative work I conducted in preparation for my field deployments. Chapter 3 covers my prior work studying the American Horsepower Challenge (AHPC), a pedometer-based pervasive health competition for middle school students. This work was conducted in collaboration with other Georgia Tech PhD students and faculty, and inspired my approach to the dissertation. In Chapter 4, I describe a series of participatory design exercises I conducted in order to understand adolescents' priorities with respect to pervasive social fitness applications (RQ1). In Chapter 5, I describe a formative evaluation of the StepStream 'prototype' that I conducted alongside the final year of participatory design sessions.

In Chapter 6, I describe the design of StepStream, a social tool for everyday adolescent health. StepStream is a pedometer-based social fitness platform for middle school students, and I describe the design in three parts: the design process and guiding principles; the technological design (including the website, pedometers and base station); and the design of StepStream as a school-based deployment and socio-technical system.

I then discuss my evaluations of two configurations of StepStream: a 'self-tracking' version deployed at one school, and a 'social' version deployed at another. In both schools, groups of students used StepStream to track their physical activity, but the system features

and social dynamics varied. The ‘social’ deployment is described in Chapter 7, and the ‘self-tracking’ deployment is described in Chapter 8.

In Chapter 9, I reflect on the dissertation. In this chapter, I tease out various topics that emerged during my studies, focusing particularly on the blended online/offline nature of StepStream and its impact on attitude change and future deployments in the field. I also outline opportunities for future work. I conclude with Chapter 10, summarizing the deployment and re-stating my thesis and contributions.

## CHAPTER II

### RELATED WORK

In this chapter, I introduce the motivating issue of adolescent obesity, present several behavior change theories relevant to my work, and describe related systems in HCI and Health Informatics.

#### ***2.1 Motivating issue: adolescent obesity***

Adolescent obesity is an important motivating issue, and presents serious challenges to health researchers and creates a valuable opportunity for social and pervasive computing research. Adolescence, a term generally used to describe people between 12 and 18 years of age, is the developmental stage where people enter into full personhood, and a time when many lifelong habits are established [42]. This extends to health behaviors: adolescent obesity is the single biggest predictor of obesity in adulthood [14].

This is particularly troubling because adolescent obesity is at historic levels: over the last 30 years, adolescent obesity rates in the US tripled [14]. Adolescent obesity appears to have leveled off in the last several years [61], and despite early reporting from a recent study that early childhood obesity had dropped precipitously [83], these signs appear to be a statistical anomaly [6]. Further complicating matters is the strong link between childhood obesity and poverty: children and adolescents living in lower-income homes and neighborhoods are far more likely to be overweight than the national average [49, 64].

Early adolescence is also marked by a decrease in physical activity overall, a phenomenon known as the “adolescent slump”. Around age 12, adolescents’ physical activity levels drop dramatically, and in many cases never recover [72]. This is particularly worrying, because health researchers and practitioners overwhelmingly agree that physical

activity is an essential element in child wellness [54, 70, 82]. Lower-income adolescents face additional barriers because their neighborhoods are less ‘walkable’ [60, 74, 76]

Yet health experts agree that solutions need not be dramatic nor expensive. Even the simple act of walking more each day has lasting benefits [27]. Additionally, addressing activity levels for obesity prevention may be especially productive: lower physical activity levels are a key correlate of obesity in adolescence, even more so than diet [80], so increasing everyday physical activity may have additional impact.

Pervasive computing technologies may be able to play a useful role here. Fitness levels can be measured by pedometers (which are a generally reliable indicator of overall physical activity [19, 44]), and wireless networked pedometers can provide “ground truth” data in new ways. Physical activity sense data is tractable: it is a quantitative variable that adolescents can directly affect, as opposed to secondary factors such as weight or nebulous concepts of overall ‘health’.

## ***2.2 Psychosocial models of health behavior change***

Health informatics researchers leverage a number of theoretical frameworks to inform the design of persuasive systems for catalyzing and sustaining healthy behavior. Three prominent health behavior change theories are the Transtheoretical (Stages of Change) model, the Health Belief model, and Social Cognitive Theory. [68] In this dissertation, I situate myself within the Social Cognitive Theory perspective, and also incorporate two other explicitly *social* models: Social Comparison Theory and Social Support Theory.

### **2.2.1 The Health Belief and Transtheoretical models**

The Transtheoretical model offers a guiding framework for health behavior change comprised of both stages and processes of change. In their seminal ‘Why Don’t Continents Move?’ paper, Prochaska & Prochaska outline a model of behavior change, rooted in smoking cessation research, in which people move through different ‘stages of change’ from pre-contemplation all the way to action and ultimately termination of the undesired

behaviors. [67] An intervention can be considered a success if it can be shown that participants moved from one stage to the next (e.g. from pre-contemplation' to contemplation'). Several HCI researchers have adopted this model, including Consolvo et al., who have used the model to understand pedometer-based behavioral interventions. [20] The transtheoretical model also influenced the design of MAHI, a system developed and studied within the Everyday Computing Lab. [52, 53]

The Health Belief model is a health communications framework that explains and predicts a person's likelihood to adopt preventive action. In the Health Belief model, one measures the extent of an individual's *perception* of: her susceptibility to a condition; the severity of the condition; the benefits of taking action; and the barriers to taking action. Designs based on the Health Belief model utilize cues to action aimed at changing individuals' perceptions. The Health Belief model was developed to increase rates of vaccination and other preventive actions, and is therefore a good fit for communications technology systems. It has been used as a model for many health informatics studies both in the health promotion and HCI literature. [68, 87]

Both of these theories have been influential and both are useful for understanding health deployments. However, neither the Transtheoretical nor the Health Belief model is explicitly *social* in approach. Instead, these models focus on the individual and ways that systems or health messages might best affect the individual. In studying social computing systems for everyday health, I feel it is important to ground my research in theories that account for the impact of interpersonal interaction as a fundamental motivator.



### 2.2.2 Social Cognitive Theory

For this dissertation I will focus primarily on Bandura's Social Cognitive Theory (SCT). First known as Social Learning Theory, Social Cognitive Theory explains individual behavior change within a social and environmental context, incorporating concepts from cognitive psychology and sociology. [1] In SCT, environmental factors, social groups and individual actions are reciprocally deterministic—they influence each other and changes in one (e.g. the social group) can affect the other (e.g. the individual) [33]. SCT takes an 'agentic' approach, focusing on the individual's feelings of his ability to change behavior, or self-efficacy.' [2, 8, 10] Key in this approach is a person's self-concept, or identity as a person who can change his own behavior.

Over the years Social Cognitive Theory's proponents (most prolifically Albert Bandura and colleagues) have extended it beyond self-efficacy to encompass a variety of behavior change mechanisms, particularly social influences in individual behavior. In contemporary Social Cognitive Theory, an individual's expectation of social outcomes can affect the individual's own behaviors. This concept, known as collective efficacy, describes an individual's beliefs about the ability of a group to perform concerted actions that bring desired outcomes. [55] Through observational learning (defined as learning to perform new behaviors through peer modeling) individuals can change their own behaviors in reaction to changes in social norms. Social Cognitive Theory also asserts that intrinsic motivation is the key to lasting behavior change. In order to adjust their behaviors, people must incorporate healthier activities into their sense of self; they must be able to see themselves as healthy individuals with respect to the target behavior. [55]

Social Cognitive Theory has been used within the social computing community to inform the design and analysis of persuasive systems. For example, Burke et al. have applied Bandura's models of behavior change to the study of newcomer contribution on social network sites. [11, 12] Using Bandura's theories, Burke et al. point the way to specific persuasive strategies Facebook can employ to encourage friends to facilitate a new user's

incorporation of her Facebook self into her identity. SCT has also been validated in adolescent populations, [91] although different aspects of the theory gain prominence compared to adult populations. Adolescents are more susceptible to observational learning effects [79] and their self-efficacy is more tied to an emerging sense of agency associated with their transition to adulthood. [91]

### **2.2.3 Social Comparison Theory**

Social Comparison Theory is a social model of behavior change grounded in people's observations and judgements of each other [30]. Originally developed by Leon Festinger in the 1950's, Social Comparison Theory hypothesizes that people rate themselves against individuals and groups they observe or otherwise hear about [30]. Social Comparison Theory is a 'rational actor' model: Festinger himself wrote that people are driven to "obtaining an accurate appraisal of their [opinions and] abilities." [30] In the absence of objective data, Social Comparison Theory says, people will look to their peers and social groups for an assessment of their relative abilities. Furthermore, these comparisons are more salient when others' abilities appear in line with one's own.

When applied to adolescent fitness, Social Comparison Theory suggests that adolescents will adjust their behaviors in a setting where they can compare to peers and superiors. Social comparison is, in many ways, a codification of peer pressure, and as such it cuts both ways. For some, social comparison provides the boost they need to keep up' with the crowd. For others, social comparison may become demotivating, especially if the perceived average of others in a cohort appears unobtainable (and this is especially true for minority girls) [34]. The theory acknowledges this fact, positing that when others' achievements seem unobtainable, not only will people become demotivated but they will also start tuning out social indicators.

### **2.2.4 Social Support Theory**

Social support theory offers another social motivation strategy, arguing that positive social encounters and discussion are likely to lead to sustained behavior change [18]. Peers, parents, teachers and other people in childrens' lives can provide social support in many ways; prior work in HCI has focused on companionate (joining or encouraging activity), esteem (encouraging confidence) and informational support (providing tips or strategies) [18].

Social support is also useful because it explicitly discusses the benefits of both *receiving* and *providing* social support as independent yet related factors. That is, a person may reap benefits from social support not just by receiving it, but by giving support to others. Furthermore, if a person only gives or only receives social support, its' effect is reduced—social support works best when it is mutually reinforced. This factor is especially important for peer support systems like the ones I have developed and studied, where all expertise, advice and behavior modeling comes from the very people who are also receiving that support. Social Support Theory emphasizes the importance of fostering a generous and open community as an essential component of any multi-user health behavior change intervention.

### **2.2.5 Opportunity: self-efficacy beyond the individual**

Previous systems have taken advantage of self-efficacy theory to motivate behavior and attitude change. However, other parts of self-efficacy have been underexplored in social computing systems for health. Over the years Bandura and others extended self-efficacy to encompass a variety of social influences on individual behavior. We highlight two: collective efficacy and observational learning effects.

A direct corollary to self-efficacy, collective efficacy describes an individual's beliefs about the ability of a group to perform concerted actions that bring desired outcomes [55]. Collective efficacy takes the social nature of individual effort into account, and focuses on

the extent to which a student believes higher fitness levels are normal and achievable by her and her classmates.

Self-efficacy theory also offers a potentially less demotivating alternative to social comparison: observational learning effects. Through observational learning (defined as learning to perform new behaviors through peer modeling) individuals can change their own behaviors in reaction to changes in social norms, rather than just comparing themselves to high-performing individuals [55]. Critically, observational learning effects have been shown to be especially effective in adolescent-focused behavior change applications [79] and adolescents' self-efficacy is more tied to an emerging sense of agency associated with their transition to adulthood [91].

The difference between designing for self-efficacy and designing for collective efficacy and observational learning is a subtle but important one. Prior systems designed for social comparison typically allow students to directly compare their activity with other individuals. Observational learning effects, however, would tend to emphasize a comparison to the group. Combined with collective efficacy, there is an opportunity to reflect group success back to the individual as a motivational tool without competition. Additionally, few pervasive health systems design for peer social support (which involves the user as both giver and recipient), opting instead for the more egocentric model of social comparison. Instead, pervasive social computing systems based on peer encouragement and social support, powered by observational learning, offer the potential to reflect a group sense of expertise and success back on the individual.

### **2.2.6 Opportunity: designing for attitude change**

One common feature of all the theories described above is the importance they place on attitude change as a requirement for sustained behavior change. In Social Cognitive Theory, this takes the form of a person's belief in their own ability to achieve a desired behavior; in Social Support Theory, people's motivation is related to their own perceptions of the

support they give and receive from others. Therefore, while designing for behavior change is certainly important for many health interventions, designing for attitude change is more important because of its direct relation to long-term motivation. This is especially true for relatively short-term interventions, during which behavior changes may not be statistically significant or may fade quickly. A system designed with attitude and behavior change in mind, according to social theories of behavior, is much more likely to make a long-term impact on behavior. Thus, when evaluating the ‘success’ of a given system, it’s important to understand the system’s effect on participant attitudes.

## **2.3 Systems**

In this section, I describe relevant pervasive and social behavior change systems for adults and youth. I group these into several categories: obesity prevention systems, pervasive social systems for youth, and school-based competitions.

### **2.3.1 Obesity prevention in HCI research**

In recent years, the HCI community has devoted serious attention to obesity prevention interfaces and systems. Much of this work focuses on individual health goals for adults, augmented by tracking and visualization technologies. For example the Ubifit Garden project showed participants a passive visualization of their own physical activity on their cellphone wallpapers. The more activity they did throughout the day, the taller the plants and flowers grew [14, 21, 80]. This approach has since been integrated into commercial products; the Fitbit pedometer shows a similar visualization at the press of a button [9, 31]. Others have focused on social and peer influence in obesity prevention. Consolvo et al.’s Houston, for example, provided a small group of friends a view of each others’ step counts [19, 58]. Fisn’n’Steps provided an ambient fishbowl visualization in an office environment; as participants took more steps throughout the day, their fish increased in size [47, 88].

### **2.3.2 Exertion interfaces & exergames for youth**

Adolescent fitness research in HCI has long focused on augmenting the experience of exercise: providing immediate tracking and rewards for exertion and making the process more fun. This approach, adapted from Mueller’s “exertion interface” concept [59], has been shown useful in lab and classroom settings. For example, Berkovsky et al’s “Play, Mate!” system leveraged a marble game mechanic: as participants moved their bodies, a marble moved through a 3D world towards a goal [7]. However, there is little evidence that short-term exposure to exertion interfaces has significant long-term attitude and behavior change benefits [44]. In response, HCI health researchers have called for more focus on theory-based attitude change as a metric for success, rather than relying on short-term activity gains [44].

MacVean and Robertson’s iFitQuest system [50] is an example of an exergame explicitly designed to increase self-efficacy for adolescent fitness. iFitQuest is an iOS-based mini-game system in which a group of 12 adolescents met several times a week for 20-30 minute outdoor exergaming sessions supervised by their teacher. Students played mini-games that encouraged them to run and jump around a common playing field. iFitQuest is interesting because it encourages students across activity levels: students play next to each other, but each student’s score is relative to individual performance and goals. The iFitQuest study showed encouraging improvements in participants’ self-efficacy for fitness, their belief in their ability to meet fitness goals. However, the sensor data indicated a novelty effect over time, with students gravitating to lower-intensity games as the study progressed.

### **2.3.3 Pervasive social systems for youth**

Other adolescent fitness systems in HCI focus on direct social comparison. These systems have mainly been deployed outside the school setting, focusing on small groups of close friends. Chick Clique, for example, allowed up to four girls to see their own progress and that of three close friends [59]. Participants in the study wore pedometers and entered their

step counts into the system. These steps were immediately visible to other participants. Chick Clique proved encouraging; the girls in the study felt supported and motivated by the social presence of their close friends. However, such small-group systems may be challenging to scale: group selection appears to be important, youth must already have a supportive peer network willing to engage in direct comparison, and no such system has yet tackled the complexity of shifting friendships and relationships over time.

#### **2.3.4 School-based competitions**

I have seen the benefits of the school as deployment site for adolescent fitness systems in my own work. In 2009 and 2010, I helped study one such system: a pervasive pedometer competition called the American Horsepower Challenge, or AHPC. Developed by Humana Games For Health and sponsored by the Humana Foundation, the American Horsepower Challenge took real-world fitness data and fed it into a virtual environment [29]. Over the course of a four to five-week “heat,” 20 students in each school wore shoe-mounted wireless pedometers that uploaded students’ steps to a base station located in their school. Students could then access the game website, which allowed each student to check their individual progress as well as the progress of the school. I provide more detail about our study of the American Horsepower Challenge in Chapter 3.

Both AHPC and iFitQuest are examples of a successful school-based deployment leveraging social support. In our AHPC study, students averaged an increase in their step counts by approximately 900 steps [29]. However, we found the school-based structures that made the AHPC successful were largely emergent; the most successful schools were ones where teachers created social rituals and local incentives [58]. Moreover, we found the overtly competitive approach likely undermined the desired results. For example, some schools chose physically fit students to represent the school and increase the likelihood of winning.

That said, the social benefits of the school as a fitness deployment site have thus far been underexplored in HCI. As our study of the AHPC shows, the schoolhouse provides a

structured way for students to engage with fitness technology, providing rituals, space and time for deployments [66]. By engaging students as members of a social institution situated in a local community, school-based deployments can leverage existing social structures to promote sustained fitness practices [5].

## ***2.4 Designing for and with children***

My research draws on and contributes to a rich tradition of interaction design for and with children. I have been particularly influenced by the Participatory Design movement, in which end-users are involved throughout the design process rather than merely as testers. Participatory Design views users as key stakeholders, and technical systems as networks of people, practices, and technology embedded in particular organizational contexts [17]. Participatory Design is often used to design for and with populations traditionally left out of the design process, with an emphasis on designing in the wild as opposed to in a laboratory setting [43].

In HCI design for children, this often means working with schools, nonprofits, camps or after-school programs forming a partnership with an organization or group of participants over the course of a design project. In such projects, children can be involved merely as end users (no involvement), as testers, as informants, or as design partners (full involvement) [25]. In our research, we work with children as informants, working closely with them in phases, then designing mockups and prototypes, then reflecting these back to the participants for iterative feedback throughout the project. We also deployed a system as a technology probe, a common strategy in designing for and with children [39].

However, while many researchers employ participatory design with children, field deployments and evaluation in an authentic context are less common. In a survey of a decade of papers published in the Interaction Design for Children (IDC) conference, Yarosh et al. found only 6% of papers designed and evaluated in an authentic context, and only 31%



of studies that tested systems involved children as design partners or informants [90]. Researchers in this area have called for broadening childrens’ involvement as design partners, particularly middle-school aged adolescents [32].

## ***2.5 Addressing health disparities through HCI***

A growing number of researchers in the HCI community are examining health as an ecological issue, based on evidence from health promotion research that socio-economic disparities are reflected in healthcare and population healthiness [86]. In this context, Parker et al. argue that health promotion for lower-SES (lower socioeconomic status) communities can be seen as activism. Using this lens, they also believe that HCI health disparities research should involve participants as a community, not just a collection of users [35,62]. Maitland et al. have shown that in some cases the typical health promotion rhetoric of persuasion may not be the best fit for lower-SES populations, where the operative challenge may be one of access not persuasion, and systems focused on resource awareness can be powerful tools for addressing health disparities through HCI [51]. More broadly, Yardi and Bruckman argue that the new ‘typical’ HCI user is less likely to be white and middle class, calling on us as a community to explicitly design for low-SES and minority users [89].

## CHAPTER III

### PREVIOUS WORK: THE AHPC

I first began studying these issues in 2009, when I joined a group of Georgia Tech researchers studying the American Horsepower Challenge (AHPC). Designed and deployed by healthcare insurer Humana, the AHPC was a pedometer-based fitness competition for middle school children, consisting of month-long "races" in which groups of 20 children per school competed against each other to get the most cumulative steps. As researchers, one of our goals was to understand what strategies or environmental factors made for a successful school. We looked for patterns in surveys, interviews, site visits and log data, and a pattern began to emerge. We found that in the schools where the AHPC really worked—where students stayed engaged throughout the month, and where they maintained high step counts—the teachers in charge of the program had created local social structures to encourage students to increase and maintain healthy levels of physical activity. At these schools, students engaged in ritual gatherings to celebrate and re-motivate progress in the challenge, and teachers made both space and time in the busy school schedule for students to exercise and check their progress. Students in these schools also supported *one another*, offering recommendations for activities to do, encouraging each other, and even exercising together.

#### ***3.1 System design***

Developed by Humana Games for Health, the goal of the AHPC program was to increase physical activity among children and to support the formation of lifelong healthy habits via an inter-school competition that used sensing and feedback technologies. The primary activity of the AHPC was a virtual 24/7 "race" in which schools competed against other schools participating in the program. Students in the competition wore on-body sensors measuring physical activity; each bout of walking or running—no matter the duration or

location—earned points for the school. To determine each school’s rank in the competition, step counts from all students on a school’s team were aggregated daily to update school rankings. Student physical activity also earned them access to a virtual currency that could be used to customize avatars representing themselves within the online game associated with the program.

To facilitate the program, schools received a base station to wirelessly collect step data from the pedometers and promotional materials (e.g. posters) about the challenge. During the competition, students wore foot-mounted pedometers throughout the day and were encouraged to wear the pedometers outside of school and on weekends. These pedometers connected to a wireless base station placed in a high-traffic area of the school. When students came within range of the base station, their steps were uploaded to the AHPC server.

### ***3.2 Deployment***

Before our research group’s involvement with the project, the Humana Foundation recruited eligible schools. The schools, located in a variety of communities across the US, were chosen based on having high participation in the National School Lunch Program, a federally assisted meal program in the US for low-income students; 73.5% of students at AHPC schools received free or reduced lunch. The schools were situated in a range of environments, from large cities to rural areas. Thirty-seven schools continued in the AHPC across all three rounds of the challenge; 1,377 students started in the first round (Spring 2009) and 1,743 students participated in at least one of the three rounds. Most students were in 6th grade (age 10-11) when they began the challenge, and in 7th grade (age 12-13) when the challenge ended.

Throughout the program, representatives from Humana managed the rollout and maintenance of the AHPC in schools. The AHPC project managers operated remotely, and each

managed a region comprised of multiple schools. Our team served as an independent, objective set of evaluators; we were uninvolved in recruiting schools, setting up equipment, or providing technical support. Instead, that role was left to Humana's project managers and school district IT staff. School teachers or administrators selected students for participation in the program. Some schools enrolled all children in one classroom or grade; in other schools, participating children might not have had a single class as a group. The variety of enrollment practices afforded us the ability to see opportunities and constraints associated with incorporating physical activity interventions into school settings.

### ***3.3 Data collection & analysis***

In the course of the AHPC, we used surveys to collect information from the students, their parents, and the teachers involved in the challenge about participation in physical activities, attitudes toward physical activities and structured exercise, perceived social support for participating in the challenge, demographic information, and neighborhood characteristics. We collected survey responses from the students once during each of the first two rounds, and two times during the final round. Surveys were sent twice to the parents of the students participating in the AHPC, once during the first round and once during the second round, and teachers received surveys at the beginning (in the first round) and the end (third round) of the challenge. In total, 577 students, 380 parents and 19 teachers responded to our surveys. We also gathered website usage and pedometer log data from each child to supplement self-reports. In total, we examined 14 weeks of individual and aggregate data (including the two 4-week rounds and one 5-week round and a preliminary baseline week before the first round). We analyzed step patterns across rounds, within rounds, and within each week.

To supplement the survey and log data, I and the other members of the research team also visited 15 schools participating in the AHPC, conducting interviews and focus group sessions with over 200 students and teachers. I personally conducted four separate school

visits. The profile of the 15 schools we visited is representative of the overall group socioeconomically (71.8% of students receive free or reduced lunch); demographically (male-female ratio=1.03, similar ethnic makeup) and regionally (covering 8 states and a mix of rural/suburban/small town/city schools). At each school, we conducted a student-only focus group, teacher interviews, and individual student interviews.

Additionally, we collected website usage and pedometer log data from each child to supplement self-reports. In total, we examined 14 weeks of individual and aggregate data (including the two 4-week rounds and one 5-week round and a preliminary baseline week before the challenge began). We analyzed step patterns across rounds, within rounds, and within each week. Our technical report [29] provides full details.

### **3.4 *Selected findings***

The AHPC study has yielded findings in several areas. We proposed a set of ‘player types’ [88], examined the role of the teacher in the deployment [58], the impact of adult-provided social support in the deployment [65], and the role of the school as a deployment site [66].

#### **3.4.1 *Styles of play in group fitness interventions***

Not every child plays the same way, and not every participating student approached the AHPC the same way. Through our analysis of surveys and focus groups, we identified five archetypal ‘play’ styles in the AHPC: *achievers*, *active buddies*, *social experience seekers*, *team players*, and *freeloaders*. Importantly, we found that deploying a group-based competition does not automatically lead to cooperative behavior. Instead, it creates a myriad of behaviors based on the players’ motivation, existing athletic skills, interest, social relationships, and social status. These players also have different social influences on others in their groups. The high-level finding from this work is that not every child is motivated in the same way, and that participants may construct a variety of appropriation practices around a social health deployment. [88]

### **3.4.2 Schools as pervasive computing deployment environments**

Pervasive and ubiquitous computing technologies seem a natural fit for school-based health interventions. Ubicomp deployments have the potential to integrate with schools and the school day, leveraging computing power to let teachers, parents and students concentrate on the behavioral objectives of the deployment. They can extend sensing and feedback beyond the classroom and into students' lives after school and at home. Yet prior work offered little guidance for the design and study of ubiquitous computing deployments in schools. We came to see the value in an approach that treats the school as a social institution, one that regulates interactions through space, time, ritual and social hierarchy. We argued that schools—as established institutions with a set of rituals and norms—require new ways of designing and deploying ubiquitous computing interventions than what has been previously discussed in the literature.

### **3.4.3 Supporting ‘hidden’ stakeholders**

In addition to looking at the school as a whole, we also examined the role of teachers and other adults. The AHPC was, at first glance, technologically simple. Students wore wireless pedometers on their shoes all day during each period of gameplay. Their steps were automatically wirelessly uploaded via a base station at school, and students could access the game website from a web browser. In practice, however, the interaction between various participant groups proved much more complex, and the teacher emerged as an important stakeholder not to be overlooked in the design of school-based health interventions. Teachers took on additional work by helping students remember to wear their pedometer and by monitoring their progress in the game. They also had the additional responsibility of ensuring that students uploaded steps as well as dealing with lost pedometers and countering flagging motivation. As the central users of the AHPC, teachers deserved more support from the system, both in helping them see students' progress and more effectively delegating troubleshooting. [58]

We also looked at teachers and parents as providers of *social support*. Parents, teachers, and other adults have quite a bit of control over a child's activities and decision-making. Thus there is a role for not only considering how individuals interact with pervasive health interventions, but also considering ecosystem of social support received by intervention users, whether from other people or from the intervention itself. We found that peers were the most likely to join students in the program for physical activity. Teachers and parents played important support roles that often went unacknowledged by the students. Attempts to facilitate social support within the game interface were underutilized and underappreciated by students; even so, we believe that providing support mediated through game interfaces shows promise, but requires attention to user interface design and what motivates players. [65]

### ***3.5 Implications for future work***

The AHPC got many things right. The sensing hardware, base station and website combination worked well once the base station was connected to the Internet. The school proved to be a promising deployment environment with its own rituals and structures, and the target population is both in need of and receptive to social school-based fitness deployments. We also found many encouraging social practices, including ritual gatherings and motivation strategies, and student-led alternative play styles.

However, these practices were emergent in the field deployment, and the AHPC technology was simply not designed to support them. For example, the AHPC lacked support for *social scaffolding*: students had very little ability to communicate with each other through the system itself. Students could see their own progress and that of the entire multi-school challenge, but not that of the student sitting next to them in the computer lab (unless they leaned over and looked).

Additionally, as external researchers we had no way to affect the design of the system to test our theories, and because there were no participating schools in Georgia, I wasn't

able to observe the deployment up close. I also had little insight into the design process. Why was the system designed the way it was? What would happen if certain features were changed? Critically for this dissertation, I began to think seriously about the less direct factors that might affect such a deployment, especially peer motivation and social support.



## **CHAPTER IV**

### **FORMATIVE PARTICIPATORY DESIGN STUDIES**

In order to better understand how social features could be embedded into a pervasive health deployment of my own, I conducted a series of formative participatory design studies with local Atlanta middle school students. This work was inspired by my experience studying the AHPC, but my goal with these studies was twofold: to better understand students' priorities around social health applications, and to test how one such system might fare in a real-world test.

During the analysis phase of the AHPC, it became clear that the students were unable to give us an objective analysis of the AHPC as a design because of their close participation in the system as it existed. I met students who had used a previous version of the design (which was generally simpler to use and less slow on their school computers) but neither I nor the rest of the Georgia Tech research team encountered students who had helped design the AHPC. I began to wonder: how would students have designed the AHPC if given the chance? What would their priorities be? Additionally, I wanted to see if the theoretical understanding I had built up from reading the literature was in evidence during interactions with adolescents, specifically identity formation and social comparison.

In 2010, I began a multi-year engagement with an Atlanta-area urban school system. From 2010-2012 I worked with an existing STEM (Science, Technology, Engineering and Math) summer camp, conducting formative participatory design exercises aimed at understanding students' priorities, preferences and blind spots with respect to everyday physical activity sensing and social feedback. I worked with students likely to face adolescent obesity: low-income minority students age 11-14 living in an urban neighborhood with low walkability scores.

In the first two years these exercises were purely formative: I asked students to design a game for them and their friends that would make fitness fun and social. After the second year, I had started to observe some patterns, so I added another component; in the weeks leading up to the camp in 2012, students used a prototype version of my own pedometer-based social fitness system: StepStream (described in the next chapter). In the design exercise that year, I asked students to design a game that could be incorporated into StepStream, and to reflect on their experiences using StepStream so that I could understand what worked and what didn't. In this chapter, I report design priorities and considerations gleaned from these studies. I presented bulk of the findings from this chapter at the Pervasive Health conference in 2013 [56]. In the next chapter, I describe the prototype system itself and deployment-related findings.

## ***4.1 Overview***

Games and the rhetoric of play are often used in design exercises with youth, even if the desired artifact is not strictly a game. Designing games allows adolescents to engage in meta-cognition about priorities and incentives, and keeps the design exercise from feeling too much like 'work' [25].

Games are also a useful framing for social pervasive health design exercises. Games can act as a shared reference and communicate values through incentive structures and rule systems [9], and social games can reward identity presentation and exploration and support daily rituals and collective experiences [58]. Moreover, the benefits of daily exercise may be multiplied when groups and communities work together to create new habits. When these are connected to a pervasive health platform, presenting a health intervention as a game can increase motivation by turning everyday exercise into something fun. This approach has been shown to be particularly helpful technique for interventions that target children and adolescents [88].

However, simply calling an application a game is not enough to guarantee success. Gamified systems that “just add points” [14, 23, 27] may lead to the design of shallow, easily-abandoned novelties [14, 22]. Understanding the perspective of the people who will ultimately use a product is critical in a health application, and even more so in a game, traditionally a fun leisure activity. It is not obvious what adolescent youth want out of these experiences, and how those desires might be translated into system designs. Furthermore, researchers and designers of youth-focused pervasive social health games have many potential theories and existing best practices at their disposal, and choosing which to focus on can be challenging.

Over three summer camp engagements, I worked with groups of middle school students to help answer these questions. I focused on a population at risk to become overweight or obese: minority students from lower-income urban communities [14, 27, 86]. I worked with these students in participatory design exercises as they created concepts for health games that they would like to play. In the third iteration, in the month leading up to the design exercises, students used a pedometer-based social health platform and then worked in groups to design games that could be deployed on that platform. I analyze students’ game designs to look for trends and design priorities, and compare these designs to the results from the first two years.

Through this work, I identify students’ design priorities and predispositions—both for pervasive social health games and within the cultural context of the community I studied. I find design implications in four key areas: social presence, gender effects, incentives and competition. In this chapter, I show how these themes manifested in students’ designs and why the themes were particularly important to my participants. I then use these findings to suggest design strategies for youth-focused pervasive social health games.

## 4.2 *Method*

These formative studies were grounded in participatory design, in which participants are given a design brief and asked to creatively respond with a conceptual system or service. This is a good way to elicit feedback and allows participants to engage in meta-cognition about a concept they may not have previously considered in depth [25,32,39]. Participatory design exercises generate several types of data: design process observations, the design artifact (whether a sketch, skit, mockup or prototype) and participants' description of how the artifact engages the design brief.

In contrast to traditional Participatory Design, in which participants co-construct a product in full collaboration with designers, these studies involved participating students as early-stage informants of the design. I was most interested in using participant-involved design as an elicitation exercise to understand students' priorities and values. However, students' designs did influence the development of StepStream in key ways, particularly in the design of StepStream's 'PuddleJump' game. Instead of working with children as 'design partners', I involved them as 'informants' (as described in Druin's four roles for children in the design of new technology) [25]. Students' views and design priorities strongly influenced the eventual system design, but students were not co-designers.

In the participatory design sessions, students worked in small groups of three to five students to design a social game for health that they and their friends would want to play. I also conducted focus groups and informal interviews, distributed surveys and collected field notes about the students' designs and design priorities. I then analyzed the students' designs using iterative inductive qualitative analysis.

I conducted and analyzed these formative studies in collaboration with my colleague Jessica Pater. I designed the study and took the lead in running the study and analyzing the results, and Jessica helped to give feedback to students and to analyze the findings.

**Table 1:** Summary of methods and participants by year.

Year	Students	Games	Method/Data
2010	39 (22m/17f)	9	1-day participatory design (prototypes + presentations)
2011	45 (18m/27f)	14	2-day participatory design (posters + skits)
2012	28 (14m/14f)	7	3-week technology probe, 2-week participatory design (videos)

#### **4.2.1 Participants**

112 students from three middle schools in the same school district participated in the formative design studies. The racial demographics of these three schools were very similar: 80% African American, 9% Hispanic, 9% Caucasian and 2% Asian. Students were drawn from schools in lower-income neighborhoods where at least 40% of students qualify for free or reduced lunch (known as Title 1 Schools). Students were invited to participate in the camp by teachers and administrators, whom I asked to choose a mix of students representative of the school as a whole. The Average Adjusted Gross Income of households in the catchment area is approximately \$38,700, and the crime index is almost double that of the state average [22]. Over the three years, 57% of participants were female and 43% were male.

#### **4.2.2 Participatory design exercises**

In the participatory design exercises, I played the role of client. Students' presentations took the form of advertisements or trailers to convince their peers to play and to convince us to fund the project and build their game. When a group was ready for an intermediate feedback round, I would have them run through their current presentation and give them suggestions for improvements.

Although the design brief and general process has been similar each time, I have expanded the scope of the exercise each year. In 2010, the exercise took place during one day (about four hours), with students designing in the morning and presenting their designs in

the afternoon. In 2011, I expanded the exercise to cover two days (about eight hours) and to include a round of review. In 2012, students spent about 14 hours on the project across seven days, with multiple rounds of feedback. I also evolved the design strategies I employed. Inspired by the Neighborhood Networks project [24], in 2010 and 2011 I focused on physical prototyping, giving students a variety of foam blocks and craft supplies. Students presented their work to each other through presentations that included skits of their games being played. In 2012, students spent the first week designing their games, and the second week shooting and editing three- to four-minute movies using Apple iPads. The movies were shown on the last day of the camp. Each student also received a DVD copy of the videos to take home. The videos described students' games and showed simulated gameplay.

#### **4.2.3 Social pedometer platform development**

In the Spring of 2012, prior to attending camp students also used a pedometer-based social fitness site I designed called StepStream. Each student received a pedometer. Students were invited to manually enter their daily steps, either on the website or through an SMS system. When a user entered steps, the system reported “activity points,” designed to be relative to a student's typical day. StepStream was open only to study staff and participating students, and was developed on top of the microblogging platform StatusNet. More information about the StepStream prototype can be found in the next chapter.

In the version deployed for this study, StepStream lacked a game or other social incentive structure. I designed it this way to allow students to create their own game concepts during the participatory design exercises. In this way, the system served as a guide for ideation—a platform upon which the students could design their games, allowing them to be creative when it came to gameplay but providing a baseline physical activity component so they could focus on games beyond exertion interfaces.

#### **4.2.4 Analysis**

The thematic findings presented in this chapter are drawn principally from an iterative inductive analysis of the students' game designs. I recorded photos, audio and videos of each group's presentation across the three Summer Extravaganza camps, and took field notes about my impressions during the camps. In 2012, because of the increased exposure to the students, I was often able to supplement the students' official videos with additional information based on informal interviews and the iterative feedback sessions during camp. I used all of this information during my analysis. My colleague Jessica Pater and I re-watched the videos and took notes on the game's themes and characteristics. Then we discussed emergent themes I had seen individually, agreed on a common set, and individually re-coded each presentation based on those themes. We then met again to rationalize our themes and re-applied them to each game design.

### **4.3 *Design strategies***

My participatory design studies over these three years generated a fascinating set of game designs, from fighting princesses to virtual pets. But they also reveal the students' priorities, knowledge and desires with respect to pervasive social health games. In this section, I describe the four most salient characteristics of such systems: social presence, incentives, gender effects and competition. Grounded in my analysis of the students' designs, I show why these themes mattered for my participants. I then offer evidence-based design strategies for future youth-focused pervasive social health games.

#### **4.3.1 Social presence**

A key benefit of social behavior change applications is their ability to connect individuals' solitary activities to a sense of audience, and related work suggests the effects of social persuasion are heightened for adolescent-focused systems [7]. These effects manifested in an interesting way in my analysis of the students' game designs: as a desire for real-time

**Table 2:** Student-designed games (title, year & description).

Title	Year	Description
The Sorcer's Stick	2010	Magic wand for fitness
Journey to Exercise Land	2010	Physical activity as MMO currency
Olympic Gold Medal	2010	Sports themed exergame
The Exercise Game	2010	Sensed activity turns into bus cards & discounts
The Mobile Planner	2010	Device mandates sleeping & eating times
Fitness Pong	2010	Correct answers generate points boost
Around the World Dance War	2010	Offline activity unlocks new dances
Model Me	2010	Life sim with beauty pageant mechanic
iWalk	2010	Pedometer-based walking competition
Reality Into Virtuality (RIV)	2010	Non-lethal hunting game
Uplay	2010	AR goggles get more powerful with exercise
iHealth	2010	Health sensor that docks with an iPod
Evolution	2010	Exercising gives you tokens for online games
Healthy You, Healthy Me	2010	Virtual pet mimics your workouts
Runnergy	2010	Race around a real track with virtual friends
3-Legged sack race	2011	2 people vs remote opponents
A Day in the Life	2011	Virtual world where you make healthier choices
Alligator Swamp	2011	Playground game on digital floor mat
Star Volleyball	2011	Virtual volleyball exergame
Plant Zombies	2011	Exergame tower defense
Princess Warriors	2011	Escape goblins, earn outfits
iMini	2011	Improve looks & fashion sense in virtual world
Fruit Frenzy	2011	Exergame version of fruit ninja
Rogerdatt	2011	Fighting & dressup game
Dodgeball	2011	Dodgeball exergame
Fit Ninja	2011	Learn ninja poses (yoga)
Knuckle Up	2011	Virtual boxing game
How to be a man	2011	Learn fitness & life skills
Dance Idol	2011	Record & share dancing videos
Flowball	2012	Underwater basketball
Speedmania	2012	Virtual running & parkour
City of Doom	2012	Dystopic racing game
Tri Race	2012	Race in a bike, car, or run
Tikaj Run	2012	Run through many levels
Step 2x5	2012	Dance skill challenge
Crypto Racer	2012	Race as a superhero avatar



**Table 3:** Summary of Social Presence games by year.

Social Presence	2010	2011	2012
Live play only	5	13	2
Live + asynchronous	3	1	5
Asynchronous only	1	0	0

play with friends. I coded this as a desire for social presence: the sense that others are co-participating with the user in a virtual environment [26]. This was the clearest theme to emerge from analysis. Game after game, year after year, students created games that not only required real-time participation from friends, but also made it the central focus of their games. A typical game in this respect is Fruit Frenzy, a 2011 game in which two players perform chopping motions in front of their TVs to slice oncoming virtual fruit. The game is played in person, or live, against a remote opponent, and the difficulty level matches the player’s heartbeat. Players are encouraged to ‘trash-talk’ each other and can launch items that their opponent must dodge. During the presentation, when I asked the students how they would play if their friends weren’t available, one student in the team responded: “well it has to be live, so you...play against anyone who has the game.”

This trend was so strong in 2010 that I began to worry it was an artifact of the design brief itself. In 2010, in preparation for the design exercise, I showed the students several physical activity games, including Mueller’s exergames, fitness games on the Wii Fit, and the Pokemon PokeWalker (a pedometer-enhanced edition of the popular Nintendo DS game). In 2011 I switched tactics and emphasized the asynchronous nature of such games. I also extended the exercise to include a round of review for each team, during which I asked the students to consider how their game might be played if their friends weren’t around to play right away.

However, despite my efforts, in 2011 students focused even more on live play to the exclusion of asynchronous play. In 2012, I made asynchronous play a cornerstone of the experience. I eliminated the initial presentation on games for health, and focused the design

exercise on making a game the students could play on the StepStream platform. I also added the sentence “Remember: you and your friends may not be available to play at the same time” to the design brief and reminded the students of this point during design reviews.

These changes did have an effect; many groups, when asked, were able to adjust their games to include a solo or time-shifted play option. However, analysis of the videos shows that the students still overwhelmingly preferred real-time interaction. Of the seven games created in 2012, five supported asynchronous play. However, the student videos all focused on real-time play, with only two videos mentioning offline or solo gameplay options. A good example of this tension is *City of Doom*, a zombie-themed racing game in which players must escape the city in pickup trucks before the zombies catch them and turn them into zombies themselves. If a team is incomplete (that is if not all team members are online) then the game will simulate their presence by replaying their most recent race. However, these offline players will not be able to assist the live players.

#### *4.3.1.1 Social presence: design strategies*

I wasn’t surprised that students in the study valued real-time play with each other; after all, that is the basis for traditional playground games. But as designers of social health applications for this audience, this finding presents a conundrum. Many social media are built around asynchronous interaction. While they support real-time chat, sites like Facebook and Twitter are primarily designed to be used and useful whenever an individual has the time to log on. And I know that in StepStream, apart from the initial registration session, students were rarely online simultaneously. Students logged in at different times, from home and at school.

And so we are left with a design tension: the realities of social media use vs. the gameplay practices and desires of my participants. If we want to leverage social media platforms for health game experiences, the games are going to have to support asynchronous play;

and yet, if we want to use play as a reward and a collective bonding experience around health activity, the most rewarding games may be the ones played real-time.

#### **4.3.2 Incentives**

Another feature of many social health behavior change systems is the incorporation of incentive structures. Socially visible rewards can help motivate participants, and many youth-focused systems rely heavily on ‘gamification’ mechanics that provide badges or currency for desired activity [23]. However, designers of pervasive systems that rely on rewarding out-of-game activity (sensed or self-reported) must approach incentives differently.

Indeed, I was particularly interested in how or whether students would adapt traditional incentive structures in designing games for health, where the goals are different from those of traditional leisure games. In a game for health, the game itself may be used as a reward for desired behavior, in which case the incentive structures are inverted; the game’s role is to incentivize offline physical activity, so participants spend points to play, rather than earning points through play.

In 2010 and 2011, however, most students focused on in-person physical activity games—exertion interfaces—in which the game rewards physical effort the same way a traditional videogame rewards button-mashing or simple timing. For example, in the 2011 game Fit Ninja, players simulate karate moves in order to score virtual hits on their opponents. However, in the 2012 exercise, the students were directed to design a game on top of StepStream, a system that already had a built-in ‘activity points’ incentive system. And indeed students seemed to grasp this different incentive structure quite naturally; all of the games from 2012 used the activity points to alter gameplay.

Some 2012 games used the activity points to provide extra boosts or ‘powerups’ during a more traditional incentive structure. In CryptoRacer, a fantasy racing game from the 2012 camp, players with sufficient activity points would be eligible to pick up speed boosts and

weapons scattered throughout the race track. In *Speed Mania*, a running simulation from 2012, a player's activity points determined his default running speed.

Other games used activity points as a currency for purchasing in-game items. This idea is the one incentive structure I saw frequently across all three years. In *Step2x5*, a lightly competitive dance and singing game from 2012, players could use activity points to get additional songs to sing and dance moves for their avatars. *Model Me* and *iMini*, two lifestyle simulation games from 2011, both rewarded physical activity with in-game items, such as virtual dresses and makeup.

In 2012, I also saw some interesting twists on incentive structures, even including altruistic uses of points. For example, *City of Doom* (the zombie themed racing game) allowed a player to 'rescue' another player whose car had crashed, but only if the rescuer had enough activity points. Another 2012 game—*Flowball*—even used activity points to alter the physics of the game world. *Flowball* is a two-player basketball game with a twist: the game takes place underwater. In a head-to-head game of *Flowball*, the water currents favor the player with the most activity points, making it easier for that player to score.

#### *4.3.2.1 Incentives: design strategies*

In contrast to social presence, students' understanding of incentive structures was more malleable, and the experience of using *StepStream* allowed them to visualize the game's role in incentivizing everyday activity more clearly. Students were able to understand and articulate games in which out-of-game activity is incentivized with in-game rewards. This finding suggests that designers have more freedom to experiment with incentive structures in social games for health for this population, as long as the incentives are clearly explained and connected to rewards.

### 4.3.3 Gender effects

Many commercial games, especially those aimed at children, are explicitly gendered in their approach. This can be an advantage (as ChickClique shows [85]), but what if a designer or researcher wanted to create a pervasive social health game for boys and girls in a given age group? Would it even be possible? My findings suggest some significant gender-related challenges, but also some possible solutions.

The most bizarre concept across all three years was a game called Roger Dat. In their presentation, the team (made up of three girls and one boy) described Roger Dat as “a fun exciting military game you get to do all sorts of cool things like picking your theme, dressing your avatar, picking the type of war and much more.” Gameplay featured live combat with guns and swords, but players could also pause the game to switch outfits, and use their in-game kill points to buy new fashionable clothes and accessories for their avatar.

What was going on here? Roger Dat was a compromise, an ungainly solution to a pitched battle between the three girls and the one boy on the team. From the beginning, the girls wanted to create a collaborative hangout space where players could chat, modify their avatars, and give each other gifts. The boy was uncompromising; he would not be party to such a game; only a fighting game would do. In the end they agreed to disagree. Roger Dat was a casualty of gender effects.

In his book *The Art of Game Design*, Jesse Schell describes characteristics that make a game more masculine or feminine. According to Schell, masculine games emphasize mastery, competition, destruction, spatial puzzles and trial & error, while feminine games feature emotion, real-world settings, nurturing, dialog and verbal puzzles and learning by example [78]. Seen through this lens, Roger Dat makes complete sense. The boy wanted a competitive destruction game, while the girls wanted a real-world nurturing environment focused on dialog.

To help us tease out the gender effects in students’ games, I modeled my analysis after Kafai’s ‘design feature’ technique [41]. I looked at features such as genre (Kafai found

**Table 4:** Summary of games by gendered features by year.

Gendered Features	2010	2011	2012
Highly masculine	2	6	2
Mildly masculine	4	3	4
Mildly feminine	1	3	0
Highly feminine	2	2	1

that boys tend to prefer ‘adventure’ games with questing and achievements) and level of fantasy (girls in Kafai’s studies preferred more realistic settings). I also looked for Schell’s characteristics, particularly mastery, competition and dialog. I then labeled each game ‘highly masculine,’ ‘mildly masculine,’ ‘mildly feminine,’ or ‘highly feminine.’

The most ‘highly feminine’ game design was a 2011 game called iMini. This game was a virtual world that rewarded physical activity with trips to a virtual shopping mall. The game comes with several sensors (all pink) and players are directed to perform their exercises in front of a webcam. Their avatar then reflects their movements in the virtual world, and grows and shrinks as they gain or lose weight. At the end of their presentation, the four girls who designed it all chanted “Better figure, better clothes, better life, better you. iMini will be your genie!” This game contained more feminine characteristics than any other. While it rewarded mastery, it did so through dialog and real-world scenarios. The poster and game items were also all pink and purple, and all the pictures of players were female.

On the other end of the spectrum, a 2010 game called Reality Into Virtuality offered players the chance to hunt virtual animals in a safari simulation. Players would step into a spherical hamster wheel, allowing them to run and look around for prey. While the six boys who presented the game were quick to mention that the guns in the game were merely “stun guns,” this game was a prototypical masculine game, focused on mastery, competition, adventure, fantasy, questing and achievements.

I also saw some evidence that students were aware of the highly gendered nature of many videogames. One 2011 game—Princess Warriors—even appeared to toy with gender roles intentionally. The three boys who presented the game described it this way: “Do you want a game with action? (Yes) Do you want a game with princesses? (Maybe) Then you should play Princess Warriors. Studies show that Princess Warriors should be played by obese ladies and vicious guys!”

However, this game hardly subverted gender roles; instead, the inclusion of the princesses served to reinforce the masculine nature of the game, and a gameplay analysis backs this up: the game consisted of violent fantasy fighting, and involved direct competition and mastery.

One note: when I talk about ‘gendered’ games, I use that as shorthand for specific masculine and feminine archetypes, not a deterministic statement of exclusivity. Indeed, in my study I saw both boys designing feminine games and girls designing masculine games.

#### *4.3.3.1 Gender effects: design strategies*

Despite the prevalence of gender effects in students’ games, my experience from the 2012 camp shows that gendered game design issues can be addressed, although not altogether eliminated. Racing is an interesting genre solution because it can accommodate some traditionally masculine design elements (competition, muscle cars, athleticism) without requiring others (gore, fighting, war). The racing metaphor has been used in other health games—such as the American Horsepower Challenge—and I believe its relative gender-neutrality is a big reason.

When it comes to gender effects for these types of pervasive health games, designers are left with several options: design separate games for boys and girls, and risk fragmenting the population (and alienating boys who like feminine games and girls who like masculine games); design one game with modifiable ‘skins’ so participants can choose to add their own gender expression to the game; or design one game with universal appeal. But we

should not forget the lesson of Roger Dat: mix gendered gameplay elements carefully, or the result might be a game nobody wants to play.

#### **4.3.4 Competition**

Competition in a youth-focused social health intervention can be a strong motivator for some students. Indeed previous studies have shown competition-focused systems to have great promise [29]. But competition may not be the best approach for every system, and I wanted to understand its role with more nuance. The results show that students are willing to consider a wide range of competitive and collaborative mechanics. This category is also intertwined with gender effects; on average, boys tended to design more directly competitive games, while girls tended to more collaborative ones.

Students approached competition in their games in diverse ways. In my analysis, I identified four competition types, covering a spectrum from direct competition to non-competitive collaboration. I also identified games that contained elements of both: ‘side-by-side’ competitions and competitive collaboration games.

In 2011 in particular, I saw many designs that were directly competitive. Boxing game Knuckle Up, for example, allows two players using motion-sensing boxing gloves to compete against each other in a virtual knockout contest, whether they were together or at different houses. At the other end of the spectrum, several designs were not competitive at all, and instead focused on collaboration. In Model Me, a lifestyle simulation game from 2011, play primarily consisted of hanging out with friends and playing dress-up with their avatars.

Some games contained elements of collaboration and competition, often encouraging collaboration against a common enemy. For example, in 2011’s Alligator Swamp, one player is the alligator and the others are frogs. Play occurs on a large sensor mat divided into ‘lily pad’ squares and ‘water’ squares. The frogs can only move on the lily pads and the



**Table 5:** Summary of games by competition types by year.

Competition Type	2010	2011	2012
Direct (versus) competition	1	7	1
Side-by-side competition	6	3	4
Competitive collaboration	1	3	4
Non-competitive collaboration	2	1	1

alligator can only move on the water squares. In the game, frogs work together to outwit the alligator but also compete against each other to be the last player standing.

#### *4.3.4.1 Competition: design strategies*

I also identified a set of game designs that—while competitive—seemed to focus less on the competition than on side-by-side experience. Many of these were racing games. Interestingly, although these could be seen as directly competitive (and indeed many commercial racing games are), in their presentations students tended to focus on the fun of racing together rather than the thrill of coming in first. We coded most racing games as ‘mildly masculine’ because they included competition and fantasy (both traditional attributes of masculine games) but the focus tended to be social presence rather than achievement or mastery. Indeed, while competition is traditionally seen to be a masculine trait in games, the findings show that girls may be willing to accept competitive games if other aspects of a game are less traditionally masculine.

An interesting example of this is TriRace, a game from 2012 designed by three girls. Initially, two of the girls wanted to create a collaborative construction game much like Minecraft, but the third girl was uninterested and wanted a more competitive design. They settled on a racing game that encouraged social interactions rather than winning. In their video, the girls advertised the key benefit of TriRace this way: “You can race with other people on a bike, in a car, or just running.” Based on their presentation and my informal interviews with the team, the girls seemed to view their racing game as an excuse for social interaction, rather than a chance for achievement.

The gendered nature of competition in pervasive health games is an important consideration, and work in the health promotion literature has shown this to be a concern with similar populations to my participants (lower-income, predominantly African American middle school children) [81]. However, over the course of this study I have seen some evidence that gender effects in competition can be mitigated, through indirect or ‘side-by-side’ competition.

#### ***4.4 Design strategies: discussion***

In addition to the four main themes uncovered in analysis, I have also learned much about designing and deploying research systems: the tensions in designing games for pervasive health deployments, the advantages of my deployment-with-design strategy, and finally the importance of participatory design when designing for lower-income youth.

##### **4.4.1 Design conundrums**

The rhetoric of ‘play’ has considerable power for pervasive health interventions, but some challenges remain. Games can take a topic like physical activity and make it actionable and reasonable. A game setting allows kids to be a little bit weird and engage with an otherwise sensitive topic. However, pervasive health behavior change applications may make it harder to deploy the live interaction students valued so highly. This tension creates a design conundrum: how can we support the social presence students wanted while also supporting the asynchronous interactions that are more likely to occur? Moreover how can we reward offline physical activity as part of a shared social activity?

Additionally, correctly aligning rewards and incentives to encourage low-activity players requires careful thought, particularly when it comes to rewarding physical activity. A strict steps=points approach would reward the already active, making competition less appealing and undermining behavior change goals for those with below-average activity baselines. I hope others can use these experiences and design strategies to identify the challenges that matter.

#### **4.4.2 Designing beyond the artifact**

Students shared much more with us than just their perspectives on fitness games. Throughout this project, students occasionally gave us glimpses into their own daily lives. In one particularly poignant game design from 2011, a group of three boys presented a game called *How To Be A Man*. In this game, the player's father has recently gone to prison or died (both descriptions were used in the presentation), and now the player must become the man of the house. In the game, the player becomes more fit through exergaming so "he can defend his family and be the man of the house." The game also allows the player to learn marketable skills so he could earn money to support his family.

I also saw reflections of students' socio-economic status in other game designs. Several games allowed players to earn real-life money and gifts through gameplay. For example, in one game design from 2010, a group of three girls presented a game called *Model Me*. This game helped players to "find a job and get money, compete in pageants and earn prizes." Players could then collect that money for use in the real world. In another game from 2010—*The Exercise Game*—players could convert activity points into money for the bus "so if you don't have money you can just walk more so you can get where you need to go" or for use as currency in real-world stores.

Students also reflected their surroundings to us. In several of the 2012 racing games, students drew roads and cityscapes for use as backgrounds in their videos. All of these featured cracks in the sidewalk, potholes in the streets and crumbling buildings.

There are no easy design implications to be taken here. Should we incorporate crumbling buildings in my game designs? Such a direct approach might trivialize these students' life experiences; indeed I suspect my participants would rather a pervasive health game provide a brief respite from these troubles. This doesn't necessarily require full co-design, but involving participants in the design process is essential, lest we lose necessary context beyond the artifact.

## **4.5 *Summary***

The series of participant-involved design exercises described in this chapter allowed me to better understand the tensions and priorities adolescents with respect to the design of everyday fitness technologies. While none of these designs led directly to a system design of my own, I used the four themes identified here (gender effects, competition, incentives, and social presence) as key factors in the design of StepStream. Furthermore, the game within StepStream—PuddleJump—reflects common elements from several of the games designed here. Hopefully, future designers and researchers will benefit from this participant-led examination of pervasive fitness systems for adolescents.

## CHAPTER V

### FORMATIVE DEPLOYMENT STUDY

In the weeks leading up to the third and most extensive of my formative design studies (the 2012 study) I conducted a formative deployment of a prototype version of my pedometer-based social fitness system StepStream. This version of the system allowed me to accomplish several goals:

- Pilot both the system itself, my school-based deployment approach, and my surveys and measures
- Inform the summer camp's participatory design activities (see previous chapter) by giving students direct experience with a social health platform on which they could design their games
- Generate design implications for future versions of the system

In this chapter, I report findings from the design and deployment of the StepStream prototype, discuss issues and challenges raised by the deployment, and describe how my formative deployment influenced later configurations. Overall, my experience designing and deploying the prototype was instructive. Although the StepStream prototype did not result in attitude or behavior changes in the participating students, it did succeed in validating the general approach, supporting the design activities, and generating implications for the next version of StepStream.

## 5.1 *Prototype system*

StepStream is a school-based social pervasive fitness system for middle school students. Groups of students at a given middle school wear pedometers every day and use the StepStream website to check their progress, chat with each other and play games. In its' prototype state, StepStream used non-networked pedometers and lacked a game. In this section, I describe the technical and user experience aspects of the prototype system.

### 5.1.1 **Designing the prototype**

StepStream as a concept—and the design of the prototype version in particular—was influenced by many sources: my experience studying the AHPC, implications from social behavior change theory, preliminary findings from the first two iterations of my formative participatory design studies, and demographic considerations, such as popular social sites and students' access to computers and smartphones. I cover this design process in detail in Chapter 6, but in this chapter I'd like to call out some design considerations unique to the prototype.

I designed the prototype version of StepStream to be a *minimum viable product*. Because the prototype was designed with the dual purpose of generating design concepts as well as testing the viability of the system, I wanted the design to be functional and usable without overly proscribing user actions.

For this reason, the prototype is intentionally missing several features that a full deployment or commercial product might include. For example, although students accrue points based on their step counts, the prototype doesn't include anything for them to do with those points (such as a game). Similarly, while the prototype includes a communal chat stream, there is no 'collective' activity on the website. The prototype is also missing wireless pedometer upload (users have to manually enter their steps). This has more to do with the available technology at the time than an intentional choice. I discuss the pedometer issue later in this chapter. Finally, the prototype is also missing leaderboards, badges, and other

individual rewards that a commercial system might include. These were never included in any version of StepStream, but I discuss their possible inclusion in future versions in Chapter 9.

### **5.1.2 Technical design**

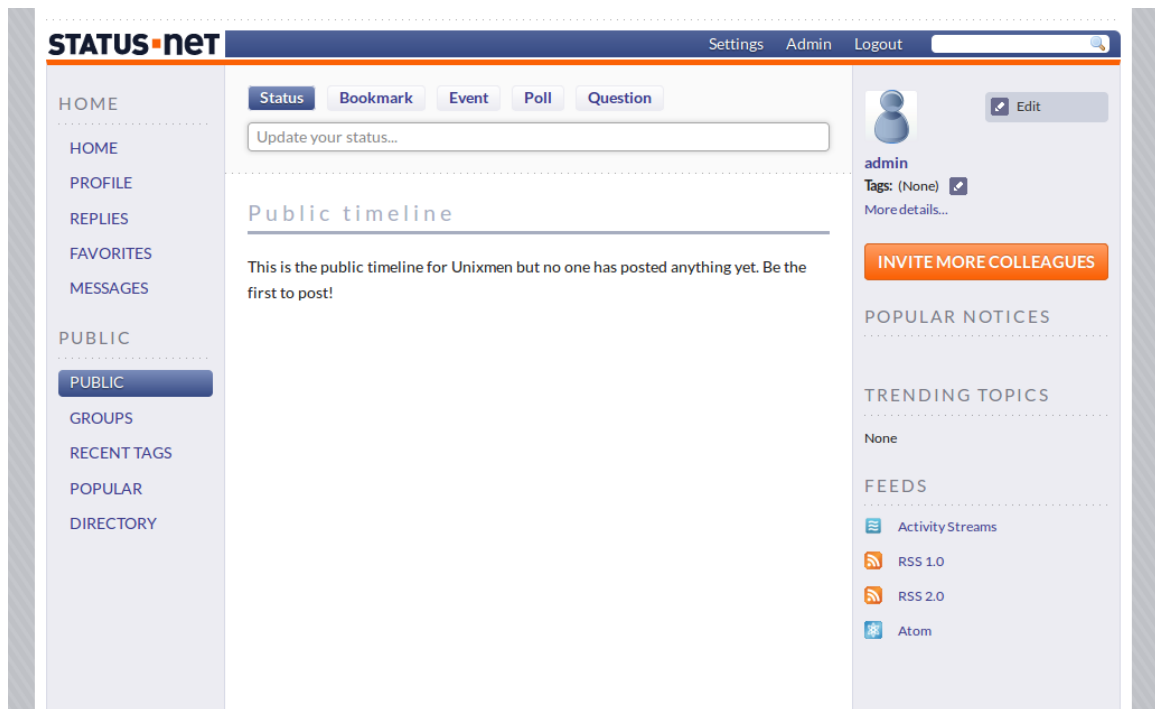
#### *5.1.2.1 Building on StatusNet*

Working with Gayathri Premachandran, a graduate research assistant in the Everyday Computing Lab, I created the StepStream website by customizing StatusNet, an open-source self-hosted microblog platform. StatusNet operates much like a Twitter clone, although it is more similar to corporate microblog solutions like Yammer. When they log in, users see a main stream of posts, and they can add their own post, or take various actions on others' posts, such as commenting or “starring” a post. Gayathri and I began customizing StatusNet in fall 2011, re-skinning our version of StatusNet to appear more youth-friendly, and using StatusNet's plugin architecture to allow students to enter their steps (either on the web or through an SMS gateway). Building on StatusNet—rather than starting from scratch—freed us from creating many lower-level features, such as user accounts and the social stream, as well as more complicated features, like SSL encryption and password-protected login.

#### *5.1.2.2 Tracking physical activity*

The StepStream prototype does not automate physical activity tracking. Instead, participants wear standalone (i.e. non-networked) digital pedometers from the GeoPalz company. These pedometers store up to 30 days of step data and have a decorative cap. Under the cap, students can see their step counts for the current or any previous days. The GeoPalz pedometers use accelerometers to estimate step-counts and feature light anti-cheating measures, such as a delay between sensing steps and adding to the visible step-count.

The GeoPalz pedometers met several key requirements for deploying pedometers to a group of adolescents for a month. They are robust; you can throw them across the room



**Figure 1:** Default StatusNet site, before customization.

time after time (and I did) without damaging them, and because they are water-resistant they will survive several trips through a washing machine. They run on a watch battery that lasts several months, and they keep a month's worth of step records. Finally, they feature a kid-friendly industrial design and do not look like typical 'health' tools.

However, from a ubiquitous computing perspective, the GeoPalz pedometers were less than ideal; I always intended to deploy the system with an automated wireless upload process like that used in the AHPC. However, the AHPC pedometers were custom-made by a white-label company and not available in the small quantities I required. At the time of the deployment (I made the pedometer decision in November 2011) there were few good options. The original Fitbit (a version of which I ultimately used in the full deployments) had one of the few open pedometer APIs that would let me collect step data and feed it into StepStream, but the version available at the time—modeled after a clothespin—was fragile, could not survive any significant interaction with water, needed to be re-charged nightly, and were designed to be synced with a home computer, requiring labor-intensive



setup for even a 30 student study. Sensors from ActiGraph, a leading pedometer in health research [4], used a closed API and cost \$300 each. Pedometers from Omron, used in many prior HCI studies, required a USB connection and stored data in a proprietary format. Smartphone-based sensors, another option one might use today, would have been impractical, especially since most students in my study did not already own a smartphone.



**Figure 2:** GeoPalz pedometer used in the prototype deployment.

After this survey of existing hardware, I opted to use the GeoPalz and to try to make data entry as easy as possible. I created an SMS interface for StepStream using the Twilio service. Students can text a four-digit date followed by a step-count. Twilio sends the contents of the SMS to the StepStream server, which checks for formatting, imports the step data and generates a post on the website on behalf of the student. Students who add their phone numbers to StepStream also receive a daily reminder to enter their steps. I also created a step entry form on the website (figure 4) that lets users enter a given date, step-count and describe how they got their steps.

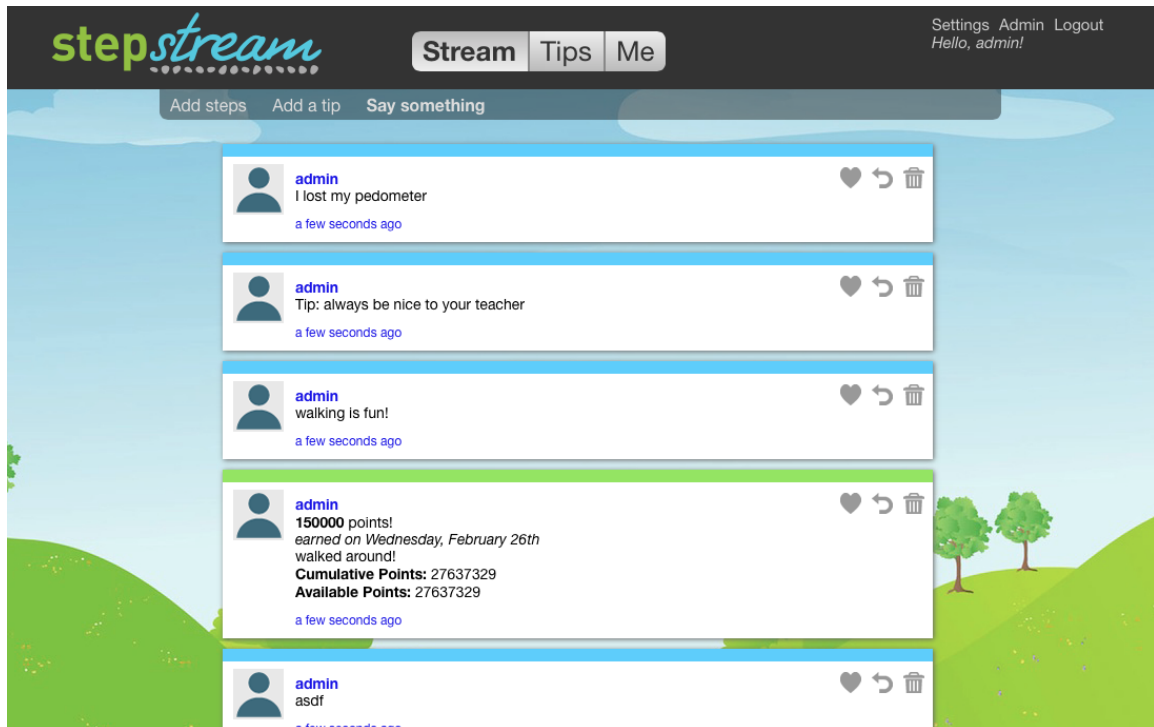
#### *5.1.2.3 Website Design*

I designed the StepStream prototype website to be simple to use, work with a variety of screen sizes, and foreground the social stream. The website has three main pages: (*Stream*,

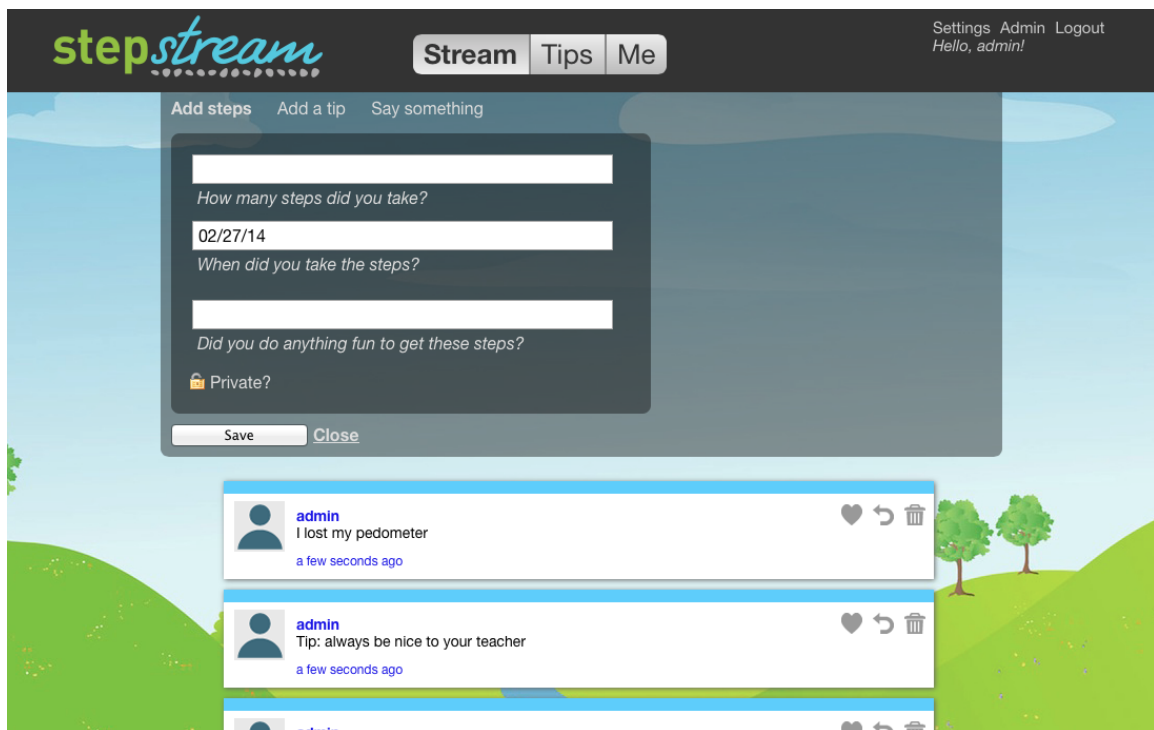
*Tips* and *Me*) and a settings page. The user logs in with a username and password, and is taken to the ‘Stream’ page. From there, she can add steps, add a tip for other users, or say something to other users. Users can ‘like’ or ‘reply’ to any post on the site, or delete their own comments or posts. The ‘Tips’ page serves as a sort of social fitness ‘to-do’ list. Users can write a tip for how to get exercise, mark a tip to remember it later, or view all tips. Tips also appear in the main stream. The ‘Me’ page shows a user her average steps per day, available points, and a historical bar chart of steps per day over the course of the deployment. The StepStream prototype does not make use of the points; they are shown to familiarize students with the concept as they design games to be deployed on StepStream. I created the logo and visual design, incorporating vector art from Shutterstock.com for the background and icons from Symbolicons.com for the actions (heart, reply, delete).

Users can enter steps, tips or a status from any page in the system by clicking on the tab underneath the header. The tab then expands, pushing the rest of the page downward and exposing the given form. When entering steps, the user enters the number of steps, chooses a date (the default is the previous day) and adds a description of what she did to get the steps. The ‘tips’ and status posts are plain-text entry forms with a limit of 1000 characters. For any post (including step counts), the user can choose to make the post ‘private’ and thus visible only to them. Every time a user posts their daily step counts, the StepStream pilot generates a post.

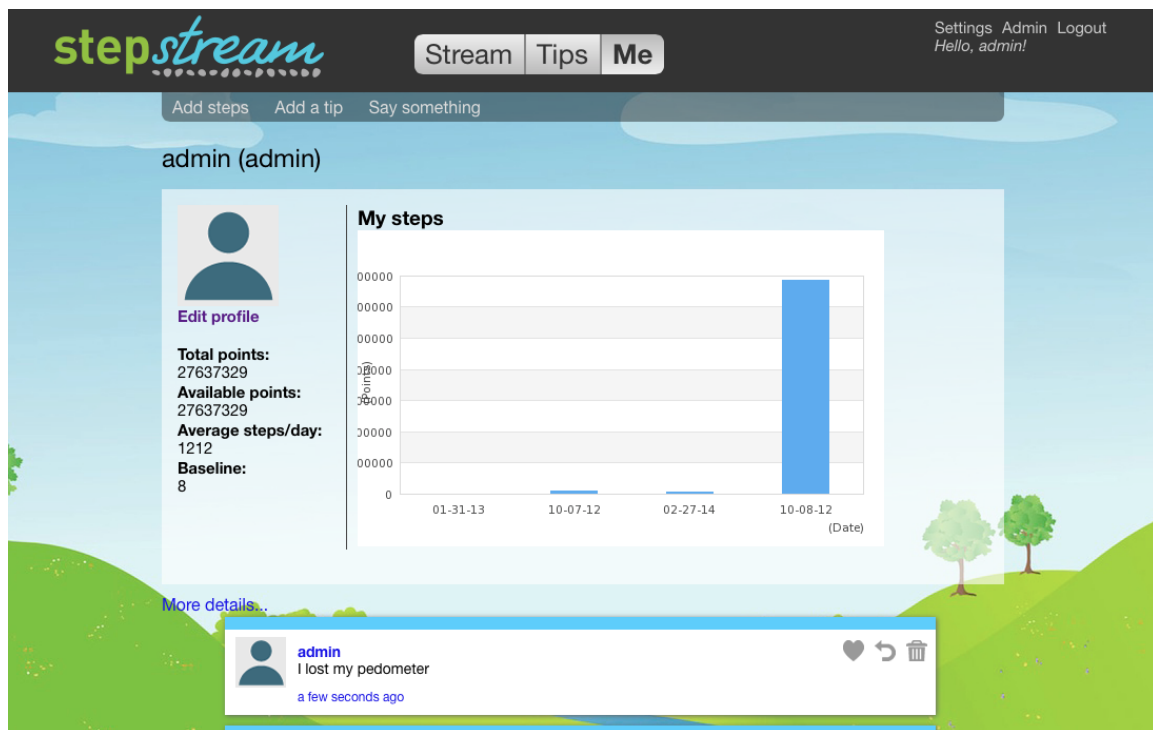
The StatusNet system updates the stream without a page refresh, so new updates from other users (whether via the website or SMS) appear in near-realtime. This feature allows StepStream to behave like a mix of Facebook (posts with comments) and a chat room (new posts appearing as they’re published). However, unlike Facebook, posts are presented strictly chronologically, so the website will remain unchanged until another user posts, likes or comments.



**Figure 3:** StepStream prototype *Stream* page.



**Figure 4:** Users can enter their daily step-counts on the website.



**Figure 5:** StepStream prototype *Me* page.

## 5.2 Method

I conducted a month-long deployment of the StepStream prototype with 30 students at a local middle school. The students received pedometers and access to the website, and used the system for four weeks total. I distributed pre and post surveys, analyzed students' pedometer and website activity, and conducted focus groups.

### 5.2.1 Deployment

30 students used the StepStream pilot for four weeks in Spring 2012 (29 days total). The deployment spanned the end of the school year and a two-week summer day camp held on the Georgia Tech campus. I began working with teachers at this school in December 2011, attending monthly after-school organizational meetings to plan the summer camp, recruit students, and familiarize the teachers with the research agenda. The research plan was approved by the Georgia Tech IRB as well as the school district's Research Department and the school's principal. As part of the school district approval process, I submitted my

dissertation proposal, a letter of support from my advisor, a description of the system, and copies of my surveys and interview prompts.

In late 2011, I and the rest of the project team met with district representatives to discuss the planned activities and purpose of the study, and these officials helped identify a school likely to benefit from an adolescent obesity-focused intervention. This school was the site of the 2012 participatory design study as well as the 2013 the ‘social’ StepStream deployment. At an evening meeting at the school in late March 2012, I presented the StepStream concepts to parents of potential participating students. I worked with four teachers at the school to recruit students, directing them to avoid choosing only physically active students.

On May 16th, 2012, I held an after-school meeting with students to begin the deployment. We first met in a classroom, where students signed in and completed a pre-study survey. Once students were finished with their surveys, we moved to the school’s computer lab. I showed them StepStream on a projector, then the teachers and I handed out pedometers and assisted students with the StepStream registration process. The meeting lasted a little over an hour. I didn’t see the students again until they showed up at the Georgia Tech campus for the summer camp, however I did monitor the StepStream website daily (partly to check it was still working, but also to make sure students did not post any inappropriate content).

At the 2012 camp, students were divided into three rotating groups of 10, and I saw each student daily. On the first day of camp (June 1st) I gave students a post-study survey. Although they were technically only halfway through the deployment, students spent the bulk of the camp discussing and designing games to be built on top of StepStream, and I felt this experience was likely to bias their responses. After students completed the surveys, I conducted three focus groups (one with each group of 10) and led the students in the participatory design exercises described in the previous chapter. I also invited students to

use StepStream for one day during the camp, and set up five computers at the back of the summer camp classroom to let students log in and use the website.

### **5.2.2 Measures**

I used a number of different measures to understand students' experience of the StepStream prototype. I distributed surveys based on those we used in the AHPC studies, collected pedometer and website usage data, and conducted focus groups with students as they worked on their game designs.

#### *5.2.2.1 Surveys*

I distributed surveys before the deployment and halfway through the deployment. These surveys were designed to expose significant changes in participants' attitudes to physical activity, sports and fitness, as well as social support for fitness. The surveys I used have been validated for use with children and are based on the survey instruments used in many physical activity interventions, including the AHPC (e.g. [40] ). These surveys are taken directly from prior work in physical activity promotion. The self-efficacy questions are taken from the SPARK school-based physical activity project [77]. I also gave students a modified version of the "Social Support and Exercise Survey", a standard measure of peer social support for exercise. To complement pedometer data, I surveyed students using the IPAQ measure for physical fitness, which asks students to report time spent exercising over the last 7 days [77]. These measures have been used extensively within the physical activity literature, and were first used in HCI by our previous study of the AHPC. I drew these questions directly from the AHPC survey to facilitate cross-study comparison. For the 'prototype' deployment, I also included questions from the Personally Expressive Activities Questionnaire (PEAQ), designed to test changes in students' perceptions of StepStream as a fulfilling and personally meaningful activity. The pre/post survey instrument is attached to this dissertation as an appendix. The surveys took participants approximately

30 minutes to complete. To analyze the surveys, I compared pre and post surveys using the Wilcoxon Signed Ranks test for within-subjects designs.

#### *5.2.2.2 Step and log data*

I collected step data from participants' pedometers while they were engaged in sedentary design activities during the camp, and then again at the end of the camp. Few students added their step-counts to StepStream itself, so I wasn't able to compare the relative accuracy of students' self-report data. With a manual upload system, cheating was a possibility. However, with so few students reporting their steps I was unable to see if cheating would be a major issue. No student who manually entered steps during the StepStream prototype had a lower step-count reading stored in the pedometer for that corresponding day.

### **5.2.3 Participants**

30 students participated in the prototype deployment study (28 of whom also completed the participatory design study that year). I drew participants from a public middle school in a large urban school district in the Southeast United States. This school was selected in coordination with the local educational authority. 72% of students at the school qualify for free or reduced meals from the Title I program, a US federal meal assistance program targeted at children in low-income households. Thirty (30) students participated in the study. Students were demographically representative of the school: 50% male (school: 53%), 50% female (school: 47%), 64% African American (school: 69%), 7% Hispanic (school: 9%), 4% white (school: 14%) and 13% Asian (school: 7%). Students were between the age of 11 and 13, and their average age was 12.5. Most students were in the 6th and 7th grade.

## **5.3 Findings**

I analyzed students use of the website, pedometers and findings from their surveys. Students attitudes and perceptions did not change significantly during the study period, and

few students wore their pedometers daily. Website use peaked during two in-person meeting days, but fell off sharply between meetings.

### **5.3.1 Website use**

The StepStream prototype recorded all messages students entered into the system, including the content of the message, what type it was (step entry, tip, or status) and a timestamp. I analyzed the messages for content, and looked for patterns of use. Students posted 181 times over the four weeks of using the StepStream pilot. Each user posted an average of 6 posts, and users posted an average of 6 posts per day. Activity on the site peaked on the two days with dedicated ‘computer time’: The initial meeting on May 16th, and June 7th when I installed StepStream computers in the back of one of the summer camp classrooms. Overall, 106 (59%) of posts occurred on these days.

37 posts (about 20%) mentioned health or fitness in some way. 29 of these health-related posts were step-count entries in which students described what they did to get steps. The most common response was “I walked”. Most posts were variations on ‘welcome’ or ‘hello’ (e.g. “hey peoples” or “WHAT YOU DOIN” or Hey supp”). Four students posted only once, but there were more than a few frequent posters. Seven students posted more than 10 times, and the most frequent two posters posted 23 and 22 times, respectively.

Students appeared to misunderstand the ‘tips’ feature and it was not widely used. The tips that students did leave were less health focused and more general (e.g. ‘Never share your password ever’ or ‘Never curse in front of a teacher #smart’). I had hoped that this feature would encourage students to share health-related tips or to organize offline activities, but it did not catch on.

### **5.3.2 Pedometer use**

Pedometer use was sparse. Twelve participants brought their pedometers to the camp for data analysis, out of which four participants had been wearing the pedometers daily. Students’ average step-counts varied widely, from 4,571 steps per day for the least active



student to 13,124 steps per day for the most active student. When I asked students where their missing pedometers were, many reported they had simply ‘forgotten’ to bring the pedometer that day, and others said they had lost their pedometer. I believe pedometer loss was the likeliest explanation, and this suspicion was confirmed in my later deployments (especially the ‘social’ deployment described in Chapter 7).

### **5.3.3 Survey results**

Overall, students attitudes and perceptions about physical activity (at least as measured in the surveys) changed little during the first two weeks of using the pilot system. There were some indications (based on an initial T-test) that social support for fitness actually decreased slightly, but none of these results was significant when analyzed with the nonparametric Wilcoxon Signed-Rank test. I attribute this relative lack of movement in survey measures to a few factors: first, that students were not exposed to StepStream significantly before completing the post survey

There is one statistically significant finding from the pre/post surveys: students reported engaging in *less* ‘strenuous’ activity each week after having used StepStream ( $Z=-2.357$ ,  $p<.05$ ,  $r=-.61$ ). However, after analyzing results from this and the two ‘full’ deployments of StepStream, I have grown to distrust results from this self-reported section of the survey. The survey asks students to report how many instances of strenuous, moderate and mild exercise they have engaged in per week, where an instance is greater than 15 minutes. In the pre survey, one student reported 20 instances of strenuous activity per week, another reported 15, and a third reported 10. In the post survey, no student reported more than 10 instances per week. I believe students were simply not able to reliably interpret this survey question. However, if the results describe a real change in students’ activity, this may also be attributable to the week off between school and camp; students may simply have been less active after a hectic school year.

## **5.4 Discussion**

The StepStream prototype served several goals. It informed the summer camp’s participatory design activities by giving students direct experience with a social health platform on which they could design their games. And it allowed me to pilot the system itself, my school-based deployment approach, and my surveys and measures.

### **5.4.1 Deployment as pilot**

As a pilot, the StepStream prototype deployment was instructive. The system remained stable and available throughout the four weeks of the study, and I was able to identify several areas for technical improvement. For example, students reported forgetting their usernames or which email address they used, so I switched to a simpler login system for the later versions of the system. These design changes are described in more detail in Chapter 6.

As a test of the school—and this particular school—as a deployment environment, the ‘prototype’ deployment was a real success. I gained rapport and a solid working relationship with the teachers at the school, and several administrators from the district came to observe the design activities and website use during the summer camp portion of the study. Indeed, I saw first-hand how crucial the schoolhouse would be in later deployments. Using this method, I was able to gather a group of adolescents with no particular common interest or affiliation to health or fitness. The participants all knew or knew of each other, but were not necessarily all best friends. The imprimatur of the school district and Georgia Tech allowed me to easily convince students and their parents to participate.

Being a school-based deployment also allowed me to make time for students to use the system. Indeed, the meeting-day peaks in message use suggest the importance of regular in-person meetings to allow students to make time for interacting with the system. The pilot also suggests there may need to be more design features to make the experience ‘sticky’.

I anticipated that the addition of wireless pedometers and a game (which I discuss in the next chapter) would lead to increased system use.

I was also able to swap out less successful portions of the StepStream system before committing to a full deployment during the school year. For example, the PEAQ questionnaire that asked students about how personally expressive or essential StepStream was in their lives was less helpful, and took a significant chunk of survey time (about 10 minutes) that I felt could be better used elsewhere. Students also didn't appear to understand 'tips' as a way to structure comments about exercise, so a future version of the system could do without them.

Finally, the prototype deployment underlined the paramount importance of finding the right sensing platform. The non-networked pedometers simply did not work as a way to give students insight into their own physical activity levels. Very few students entered their steps into StepStream during the deployment, and many students lost their pedometers in the two weeks between the initial meeting and the beginning of camp. This 'prototype' deployment showed concretely the need for a robust, wireless pedometer (as well as the need to order at least two pedometers per child when planning the next deployment).

#### **5.4.2 Supporting design activities**

As a probe for design, the StepStream prototype performed admirably. In the first two participatory design studies, I had seen indications of the themes presented in this paper, especially incentives and social presence, and I wondered whether these were merely due to the way in which I had framed the design problem during the first two years of the study. Students in the 2012 design study were easily able to imagine a game running on the StepStream platform, and their designs were varied enough that I felt they had not been unduly constrained by their use of StepStream. Students were particularly adept at leveraging the step 'points' concept for use in their game. One surprising finding that carried through from the previous two participatory design exercises was students' focus on

‘social presence’. Despite the prototype’s capacity for asynchronous interaction, students predominantly used it in person. This observation supports the finding from the formative studies that making time for interacting with the system (and with each other) is key for these adolescents.

Comparing students’ designs in the years before the deployment against their designs in the 2012 exercise, I saw their adaptability to StepStream’s incentive structure. In previous years, many games rewarded live exertion with in-game points. However, in StepStream, students are rewarded for walking with activity points, that the students could put to use in their game designs. Conversely, my deployment-then-design approach revealed the persistence of students’ desire for live social play. Even after having used a system where few users were on simultaneously, students still designed with live interaction first. In these ways, I believe the deployment helped us understand students’ perspectives more deeply, and I recommend it to others investigating this space.

### **5.4.3 Design implications**

Students appeared to take to the basic premise of StepStream, and it was clear from their designs that they were able to understand the prototype and successfully design games to work within the StepStream context. Low step-count upload (as well as low pedometer usage) stresses both the need for a wireless upload system and for some strategy to deal with pedometer loss. Students appeared to misunderstand the idea behind the ‘tips’ feature, suggesting the feature be removed or significantly re-worked. The high number of interactions with the website during dedicated computer lab sessions suggests that these be incorporated into future deployments. These regular meetings could also help with pedometer replacement and serve as a reminder for students to keep engaging with the system.

## CHAPTER VI

### SYSTEM DESIGN

Based on an analysis of previous systems (including my own experience studying the AHPC) and the social behavior change theory literature, I designed my own system: StepStream, an after-school program and social network site for middle school students to share and encourage everyday lifestyle activity. StepStream allows participating students to check their daily and historical step counts, read congratulatory messages about their fitness accomplishments and the accomplishments of their peers, write their own messages, and play a collaborative game.

StepStream tracked step counts as a proxy for students' everyday lifestyle activity. Pedometers have often been used in social fitness deployments for youth, and I wanted the physical computing portion of our system to be robust, familiar to users and easily comparable to previous work. Students wore FitBit Zip pedometers that store 30 days of activity and have a battery life of 3 months. Daily step counts were uploaded to the website through a base station positioned in a common area of the school.

StepStream was both a technological system (including pedometers, base stations and website) and a school-based program (conducted in collaboration with a local school district, including regular meetings with administrators, teachers and students). In this chapter I describe the design of the system, then outline how this system worked as part of a school-based program. Finally, I describe the influences on StepStream's design, including the AHPC, social behavior change theory, and my own formative work.

#### ***6.1 Designing StepStream***

The main goal for the design of StepStream is to understand the role of noncompetitive awareness and encouragement in the design of a pervasive social health application for

adolescents. In designing StepStream, I was influenced by several factors: my prior experience studying the AHPC, my formative studies and deployment, and implications from social behavior change theory.

### **6.1.1 AHPC influence**

The American Horsepower Challenge served as inspiration and foil for many of the design elements of StepStream. I modeled the design of StepStream after the American Horsepower Challenge (AHPC) in general approach: students from a low-income middle school wear pedometers and use the system for a month. The students use a website to track their progress. I used many of the same survey measures from the AHPC study as well as similar interview protocols for the focus groups. However, I also deviated from the AHPC in several key respects.

#### *6.1.1.1 Steps & Pedometers*

The AHPC used pedometers and daily step-counts to measure students' activity levels. Steps are a commonly used general indicator of overall physical activity levels, and pedometers are familiar and commonly understood activity sensors [19,21]. Step counts have also been successfully used in youth-focused deployments (such as ChickClique) [85]. As sensors go, pedometers are minimally invasive and can quickly become invisible in use. Technologically, the AHPC used wireless pedometers with a base station located in the school, a setup that worked well once the base station was connected to the Internet.

#### *6.1.1.2 School-based deployment*

The AHPC was a school-based deployment, and AHPC representatives coordinated with district officials, principals and teachers to gain access to adolescents in their target demographic. The schoolhouse proved an especially valuable deployment site for the AHPC, and I sought to leverage these advantages with StepStream as well [66].

In our AHPC studies we found that the school is a good place to reach a wide cross-section of youth, and a natural gathering place. Its rituals and structured interactions allow a mindful researcher the chance to work regularly with students and teachers, to make time for students to interact with the technology and each other. Because of my experience studying success and failure of individual AHPC deployments, I decided to implement StepStream as an after-school program (meeting weekly for one month) and a summer camp (for the design exercises and post-study focus groups)

#### *6.1.1.3 Low SES communities*

The AHPC focused on students in poor communities facing above-average adult obesity levels. These students are more likely to face health disparities more generally and nutrition and fitness challenges in particular. I also designed StepStream for students in low-SES communities, and I selected schools using the same criteria the AHPC used: ‘Title I’ schools with high percentages of students who qualify for free or reduced lunch.

#### *6.1.1.4 Differences from the AHPC*

The StepStream prototype differs from the AHPC in several key ways. It is non-competitive (as opposed to the AHPC’s inter-school ‘horserace’ metaphor) and has no group milestones or goals. It obscures absolute step-counts, showing ‘points’ instead. Participating students wear standard digital pedometers (instead of the AHPC’s foot-mounted wireless pedometers) and manually add their daily step-counts to the system via SMS or using the StepStream website. Most importantly, the website prioritizes social interaction, featuring a social ‘stream’ of step reports, ‘tips’ on how to get steps, and general chat.

### **6.1.2 Social behavior change theory**

Social behavior change theories—including Social Support Theory, Social Cognitive Theory and Social Comparison Theory—have many design implications for pervasive social health applications, but many of these were untested in computer mediated experiences

when I began designing StepStream. During the design process I strove to incorporate these theories into StepStream's design.

#### *6.1.2.1 Social support*

Social Support Theory suggests many ways in which people can help each other promote and sustain healthy behaviors. While this support can come from many social ties (including parents, teachers, and relatives) for StepStream, I focused on *peer support*. StepStream encourages students to both give and receive advice, encouragement, and offers of offline exercise. I wanted to see if providing a platform for online peer support would translate to support offline and ultimately to increased physical activity.

Many common social media design patterns already enable social support, and I included several in StepStream's design. For example, the "heart" feature facilitates a simple gesture of support, whereas the "comment" feature allows users to engage more directly, such as offering advice or offering to exercise with each other.

#### *6.1.2.2 Collective efficacy*

Bandura's Social Cognitive Theory [1] serves as an overall framing for my work, especially its description of how individuals, environments and social ties interdependently function in a health behavior change context. Collective Efficacy is the idea that groups of people engaged in similar tasks can participate in a virtuous cycle: if a person sees the group as a whole succeeding, they may in turn feel that they themselves are a part of that success which will then increase their own self-efficacy.

StepStream enables this sense of collective purpose non-competitively through the game. The more students play the game, the closer they all become to 'unlocking' a new level in the game. This experience gives students the sense that they are accomplishing something together, but without the competitive aspects of the inter-school competition in the AHPC.



### 6.1.2.3 *Indirect social comparison and observational learning effects*

Traditional persuasive technologies use rhetoric or other authority-based mechanisms for encouraging new behaviors, but peer social tools must leverage different mechanisms. *Observational learning effects* are a proposed mechanism for the diffusion of peer attitudes and behaviors, taken from Social Comparison Theory. Observational learning effects describe how people observe actions and attitudes displayed by peers and mimic those actions as a way to achieve their own goals. More than simple ‘peer pressure’, observational learning effects describe intentional behavior change based on what a person perceives to be normative. Although they come from different parent theories, one can view observational learning effects as a mechanism that achieves collective efficacy.

StepStream operationalizes observational learning effects in a few ways. First, every post and comment in the system is visible to all participants, giving every user the chance to affect and be affected by each other’s discussions. The deployment strategy of weekly computer lab meetings also enables observational learning effects by creating a hybrid online/offline space in which students can observe each others’ interactions.

Unlike most previous systems, StepStream is not overtly competitive; it offers no rewards for outperforming other students and there is no common leaderboard for direct comparison. The American Horsepower Challenge, for example, showed students how their school was doing compared to other schools, and focused on direct raw step count competition. Chick Clique showed users their friends’ raw step counts in a persistent list.

Even the ‘social’ configuration of StepStream carefully limits students’ visibility into each others’ progress. StepStream generates congratulatory messages for each student who walks above their baseline average. However, raw step counts were only visible to the person who walked them; students could not see each others’ raw physical activity. Instead, they see and share activity points. Each student receives 400 activity points for an average day’s steps. When a student walk more than their daily average (that is, garners more than 400 points in a single day) the system generates a congratulatory message in the social

stream for all to see. Others can not see exactly how much the student has walked, but can see the student's personalized achievement. This feature allows StepStream users to focus on personalized achievement and general awareness rather than competing directly. Instead of direct social comparison, StepStream enables an indirect means of observational learning—and made way for students to observe general trends and learn from them. In doing so, I hoped to avoid some of the more demotivating aspects of social comparison.

### **6.1.3 Influence of formative work**

The design of StepStream was also influenced by my experience conducting my own formative studies with local middle school students. StepStream's design incorporates design implications from both my formative design studies and the prototype deployment.

#### *6.1.3.1 Formative design studies*

The most direct influence from my formative work is the design of PuddleJump, the game students play in StepStream. This game was designed based on concepts from students in my participatory design studies, particularly the third year. But I also incorporated the themes from my formative studies (social presence, incentives, gender and competition) when designing StepStream.

**Social presence.** Students in the participatory design studies demonstrated a keen desire to feel their friends' presence in the final design. The social stream allows for live interaction by updating without a page refresh, simulating a chat-like experience when multiple users are posting per minute. However the stream quickly becomes 'stale' if only one user is online at a given moment (a likelihood given students' different schedules). I designed the game to simulate social presence by allowing players to play 'with' their friends. Players friends' avatars get any stepping stones found during the game, and after the game StepStream creates a post that implies the friends were playing 'together.'

**Incentives.** Students appeared able to quickly understand basic points-for-steps incentives, and their designs often included a second 'currency' or incentive system operating

independently of step points. For this reason, I felt comfortable including the concept of ‘stepping stones’ as something the students were collectively trying to gather. These were found during the game, and gameplay cost an average day’s step points.

**Gender effects.** I tried throughout to make the game appeal equally to boys and girls. In visual design, the website is candy-coated but neither overly pink nor full of skulls and guns. The game lets users play as a boy or a girl avatar, and both have the same abilities. The pedometers I chose were lime green rather than pink or blue.

**Competition.** We know competition is a strong motivator for some adolescents (and is often associated with more masculine designs, although the correlation is not strict). It was less clear from the first two years of design exercises whether students would react positively to a noncompetitive system or whether it would merely bore them. There were signs in the design study conducted alongside the prototype deployment that such a system could be successful. The game (an endless runner where the player runs ‘alongside’ their friends) represents one of the compromises suggested by my formative work.

#### *6.1.3.2 Formative deployment*

One of the key takeaways from the prototype deployment of StepStream was that the experience needed to be more ‘sticky’. That is, I needed to find more ways to engage students and encourage them to use the system. I attacked this challenge in a number of ways. On the technology side, I encouraged more posting by making the post form permanently open and changed the layout of the site so users could see more posts on the screen at once. I also made the user’s personal information permanently visible and created a large call to action to complete the current challenge (to unlock a new game level). I added a game and made it playable only after the user had taken an average day’s worth of steps. The manual pedometer upload process from the prototype deployment was also a barrier, and one that I was able to address with the release of the FitBit Zip pedometer three months before my full deployments.

Another factor driving system use in the pilot was the availability of a computer lab and a dedicated time for students to use the system. I knew based on the formative design studies that students preferred live interaction. Additionally, students' lives after school are also busy. Students in the deployment school are on campus until 4pm, and may not be home until 5pm. Given these constraints, I felt it was important to explicitly make time for system use through a weekly hour-long after-school program held in the school's computer lab.

## ***6.2 Design for comparison***

In order to better understand how various components of the system interact, and to separate the effects of the social layer from that of the overall deployment as much as possible, I designed two versions of StepStream: a 'self-tracking' version and a 'social version'. Both of these systems include the same pedometer/base-station setup and were designed for school-based deployments, and even run on the same code base. However, users of the 'self-tracking' version can only see their own information on the system itself, while users of the 'social' version can also write and respond to social messages. Both versions include a game, but the 'social' version also includes a 'play-along' mechanic where users race alongside up to three of their friends.

Both the 'self-tracking' and 'social' versions of StepStream are intentionally missing design elements that prior research suggests might be persuasive, such as leaderboards, badges, offline rewards and competition. This bare bones design allows for a greater level of confidence in the source of any behavioral or attitudinal changes seen during a StepStream deployment. Additionally, the similarity between the designs of both systems, the prototype, and the AHPC allows for a certain level of cross-study comparison. I go into this comparison in more detail in Chapter 9.

## **6.3 Website design**

As a technological system, StepStream consists of a website (where students can check their own progress, chat with each other and play a quick virtual running game), a set of wireless pedometers, and an Internet-connected base station in the school to upload step-counts from the pedometers to the website.

StepStream supports two configurations: a ‘self-tracking’ mode in which users can see their own progress and play a game, and a ‘social’ version that adds a number of chat and communication features. Both configurations run on the same code-base.

### **6.3.1 Website overview**

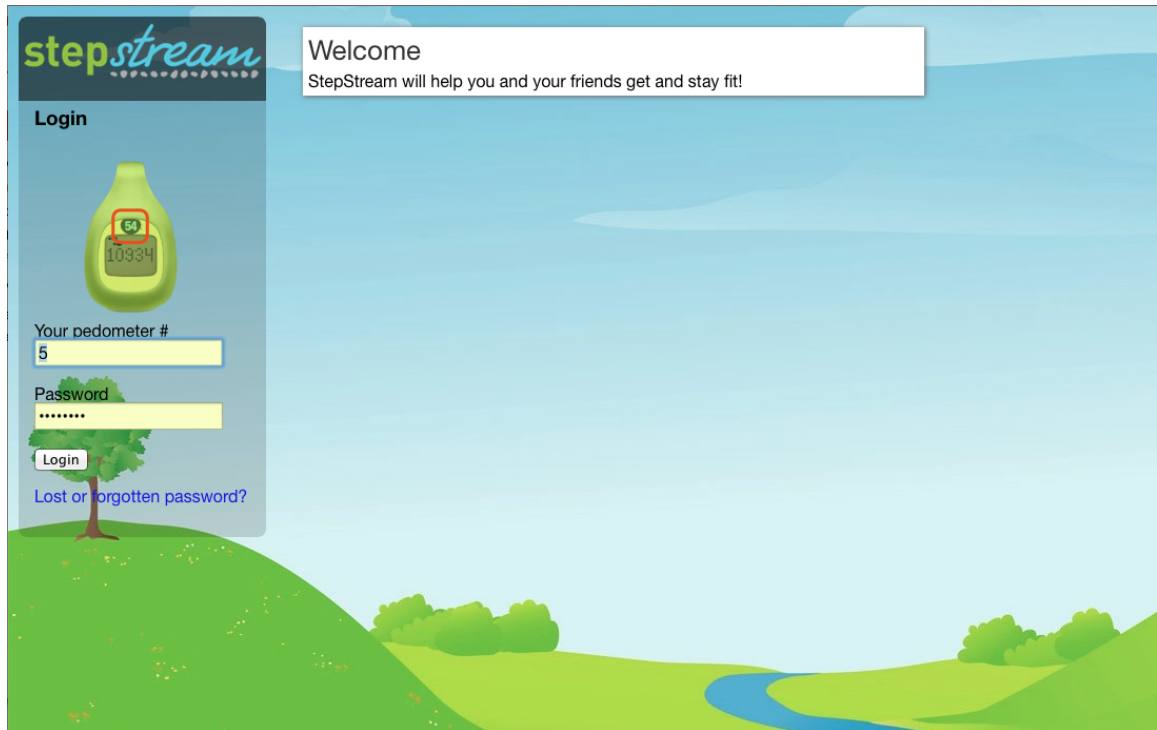
The StepStream website lets students check their own physical activity, chat with others, and play a game. The basic feature set is similar to that of the prototype, but there are a few key differences: a new ‘self-tracking’ version, a layout change, the removal of the ‘tips feature’ and the addition of a game.

#### *6.3.1.1 Layout and features*

The StepStream website is organized into four basic areas: personal, stream (for the ‘social’ version only), game and settings.

#### *6.3.1.2 Login*

Users log in using their pedometer number and a password. The login page shows the user how to find his pedometer number. Users can define a separate user name to appear in the stream, but they still use their pedometer number to log in. This modification is a design change from the prototype, where users logged in with a username and password. Students reported forgetting the username they had chosen. This change simplified login and also allowed me to pre-register all the students in StepStream before the deployment. Once students log in they can set a username and avatar for use within the site. The login screen also allows students to reset their password by email.



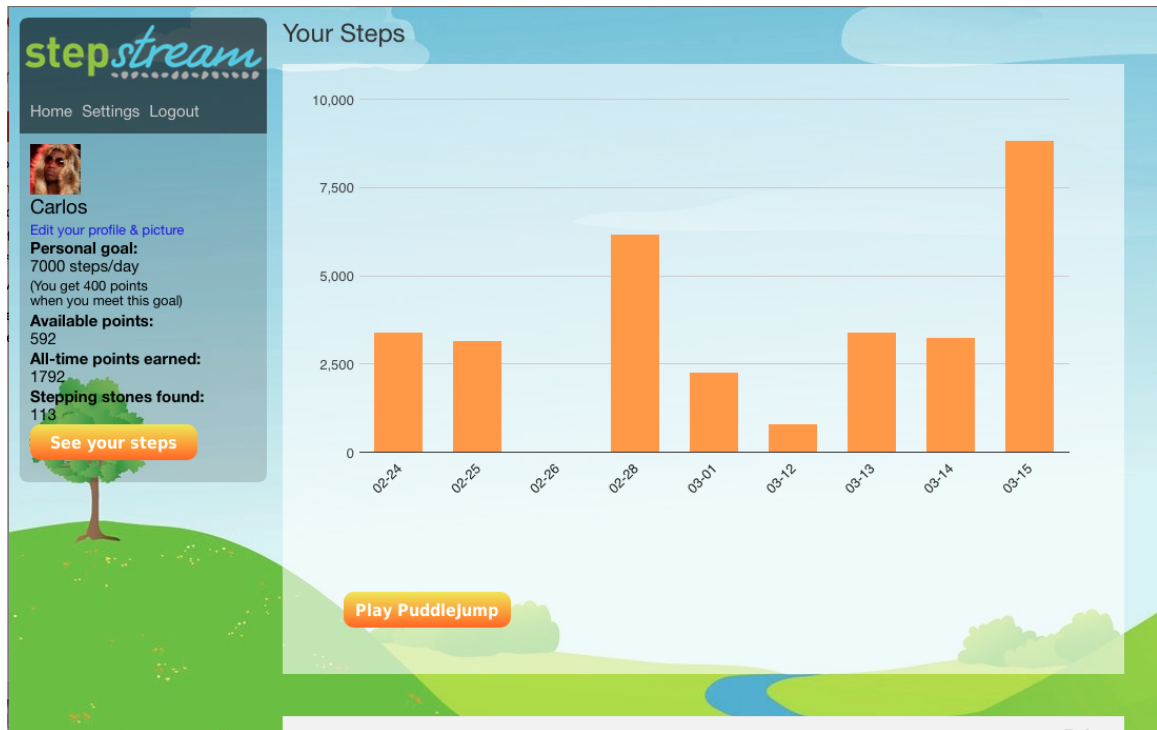
**Figure 6:** ‘Login’ page for StepStream. Users log in with their pedometer number.

#### *6.3.1.3 Self-tracking features*

In the ‘self-tracking’ configuration of StepStream, users land on the ‘Your Steps’ page. This page is also accessible in the ‘social’ configuration by clicking on the ‘See your steps’ button.

On the ‘Your Steps’ page, users can see a summary of their progress on the left, including their personalized step goal, available points, all-time points total, and the number of stepping stones they have found in the game. This side bar persists in all pages on StepStream.

The main focus of the ‘Your Steps’ page is a daily step chart, updated whenever the pedometer syncs with the base station. The user can mouse over an individual day to see a hover overlay of the specific number of steps. This page is the only place where individual step counts are shown. The user can click ‘Play PuddleJump’ to play the game, which is available in both the ‘self-tracking’ and ‘social’ configurations.



**Figure 7:** ‘Self-tracking’ configuration landing page, showing individual progress in a daily bar chart.

In the ‘social’ configuration, this page also lists every post the logged-in user has made on the site. Users can remove any of their posts or comments from the site by clicking a ‘trashcan’ icon on the post or comment.

#### 6.3.1.4 Social features

Users of the ‘social’ configuration of StepStream land on the ‘stream’ page after login. On this page they can see an overview of their own activity (taken from the ‘Your Steps’ page), see the social stream, add a post or comment, choose three friends to play with, and play a game. The social stream contains a user’s own messages, other students’ messages, records of games other students had played, and congratulatory posts for students who exceeded their own baselines on a given day. Users of the ‘self-tracking’ version of StepStream cannot access this page.

This design inverts the common approach in social fitness applications for youth. Other systems either focus on the individual's progress primarily (e.g. the FitBit dashboard) or on the raw step counts of friends [85]. StepStream focuses on what friends are saying and doing within the system.

In the 'prototype' version of StepStream, there were two different social streams: a generic stream that included step reports, user messages and 'tips', and a 'tips' stream that only included the tips. In the formative deployment, students rarely used the 'tips' feature and I felt it was complicating the experience so I removed it for the full 'social' deployment of StepStream. In its' place, the "message" prompt rotates between different prompts:

1. How's it going?
2. Share how you're getting steps!
3. Share a story about StepStream!
4. How can you get steps together?

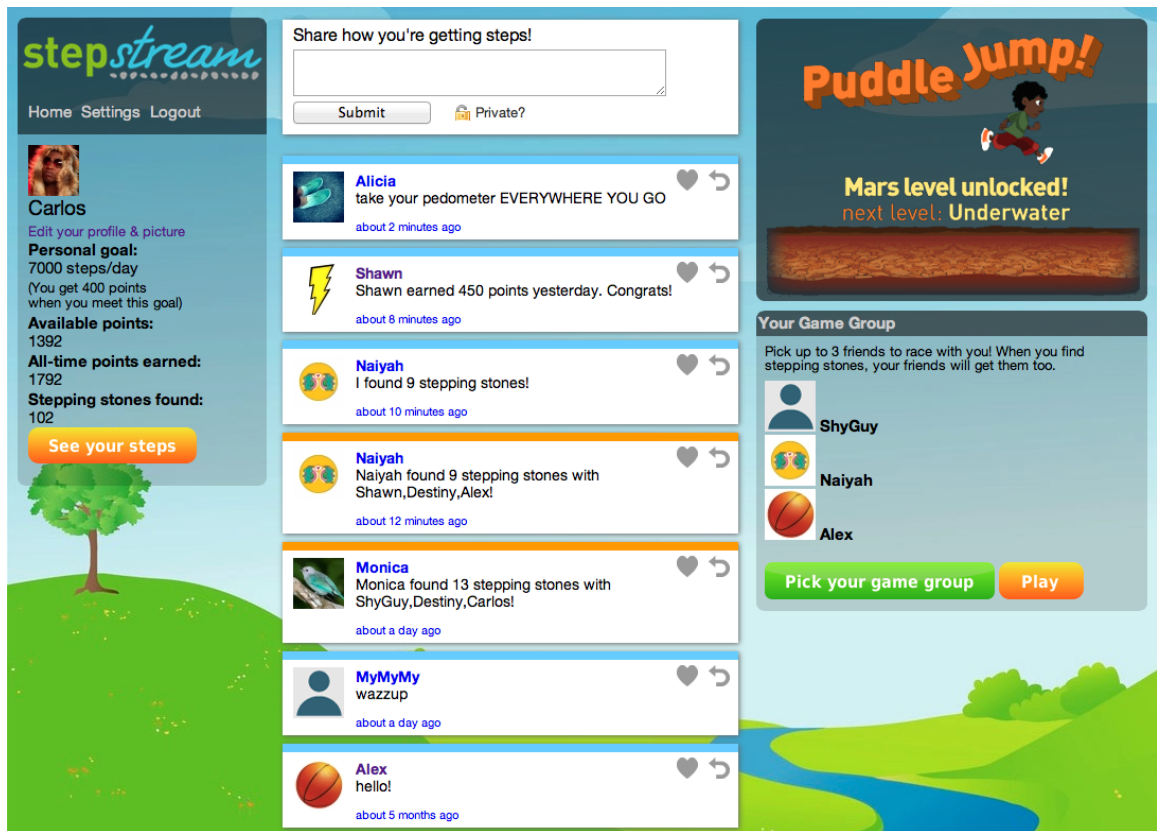
These are designed to encourage students to share various types of social support with each other, as well as to get them to engage authentically with the system.

#### *6.3.1.5 Congratulatory posts*

The stream is designed to contain a mixture of user-generated posts, automated gameplay posts (generated when a user plays a game on the site), and automated congratulatory posts when a user earned more than 400 points in a given day. Users of the 'social' version of StepStream should see a mixture of authentic posts from their friends and classmates, gameplay reports, and fitness congratulations from the system.

On the left, the user sees a summary of her personal information, including average daily steps, available points, and daily step average. The user can click to the personal section to see a historical bar chart of her steps per day. This raw data is only visible to the user and is visible on every page in StepStream. The game area of the home page includes





**Figure 8:** ‘Social’ configuration landing page: personal info on the left, the social stream in the center, and gameplay on the right.

a promo for the current level, a button to play the game, and a way to select up to three friends to play with.

### **6.3.2 Changes from prototype**

The ‘self-tracking’ and ‘social’ versions of StepStream automatically import and store users’ step-counts, show users their own progress, convert raw steps to points, let users play a game and create automated posts from the system. We also adapted StatusNet’s “follow” or “friend” system to let our users select friends for the game. The game, described in more detail later in this chapter, was deployed as a standalone Flash/HTML5 object but required a REST API to get and set users’ steps, points, and friends. The game also posted to the main stream when a user completed the game.

### **6.3.3 Game**

StepStream includes a game—PuddleJump—designed as a light reward and collective experience for participating students. The game, a quick endless runner in the style of Canabalt or Temple Run, was designed based on concepts created by students in my formative participatory design sessions [56]. PuddleJump is designed to create a common experience and be a reason for students to log in from home, creating a collective sense of achievement within and between in-person sessions. Each gameplay costs an average day’s points (400 points per play). In the game, students race through multiple levels, and must jump to avoid puddles in the road. As they play, students collect “stepping stones.” Once the students have collectively found enough stepping stones (defined manually by me depending on how the deployment is progressing), a new level in the game is unlocked. The game is single-player, but users in the ‘social’ condition can choose to play it ‘with’ up to three friends (asynchronously). When the student finishes the game, their friends also acquire any stepping stones the student found during gameplay, and the website generates a gameplay message mentioning the player and friends in the stream.

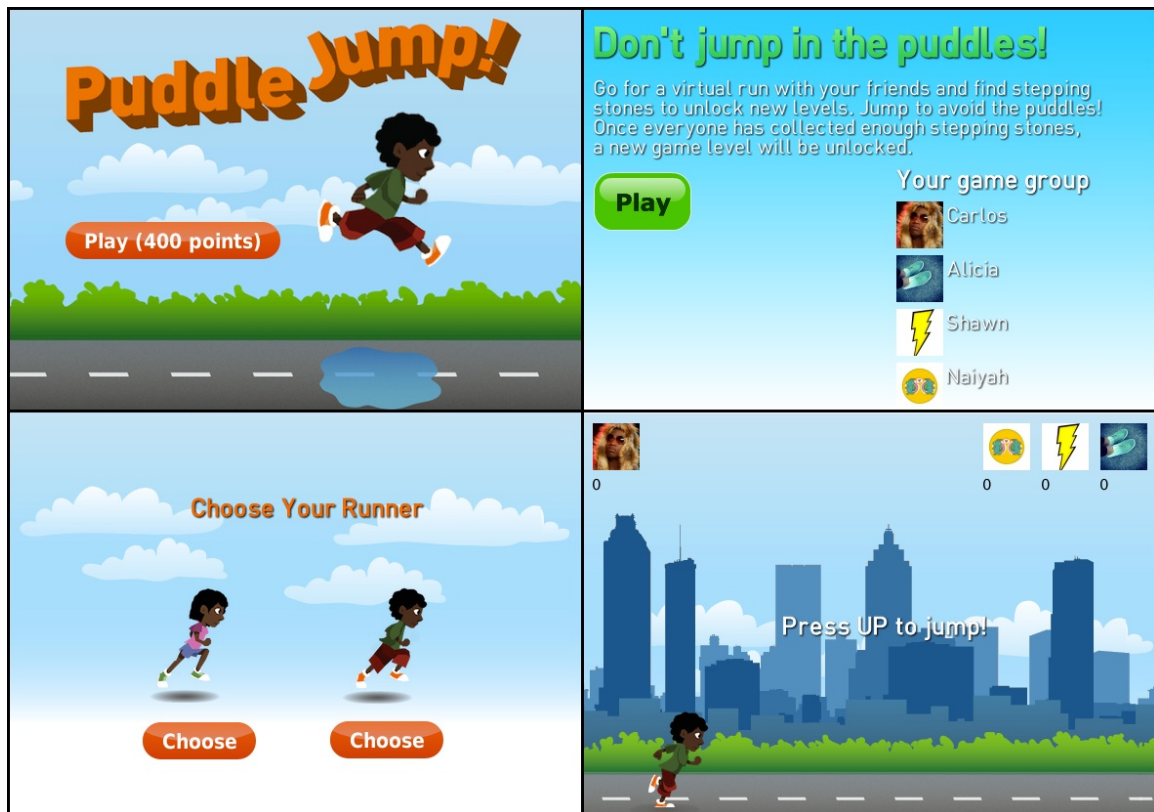
In 'PuddleJump' the user plays a runner running through the streets of Atlanta. The goal of the game is to jump over the puddles that appear periodically and collect 'stepping stones' which are floating pebbles distributed throughout the game. The longer the player survives, the faster their avatar runs, until they jump in a puddle. The game is designed to last between 30 seconds and 1 minute. Although there is no maximum time, the game does allow players who jump into puddles before 30 seconds are up to continue their game. 'PuddleJump' is a side-scrolling game deployed in HTML5 or Flash depending on the user's browser capabilities.

The game evolves across a deployment of StepStream, with new levels being 'unlocked' by students roughly once per week. Each level is designed to be visually distinct from the others, and the website features a 'promo' for the next level once a given level has been unlocked. This 'collective action' to unlock a new level of the game is designed to encourage participants to collectively exceed their baseline steps by giving them a common goal to work towards.

#### *6.3.3.1 Designing PuddleJump*

Students participating in the third iteration of my formative design studies were tasked with designing games they would play on StepStream. I analyzed these games and found several common themes: racing as a common metaphor, racing 'alongside' as a way to include social aspects in a game without too much competition, and racing through multiple 'levels'. 'Tikaj Run' and 'TriRace' were particularly inspirational. The result—PuddleJump—is an exercise-themed game starring an adolescent who looks like the users themselves trying to avoid puddles on a Spring Atlanta day.

I developed the game in Stencyl, a visual scripting environment for multi-platform games. Stencyl handled the in-game physics and other low-level tasks, and can output completed games to Flash, HTML5, native iOS or Android. I chose to write to Flash and



**Figure 9:** PuddleJump gameplay sequence: User clicks 'Play' to spend 400 points; instruction screen; Choose your runner; Gameplay with friends on the top-right.

HTML5. I also connected the game to the StepStream server to retrieve a user’s avatar, friends, available points, and to post a status after gameplay.

The game’s visual aesthetic is intended to connect to students’ experiences offline, show them a representation of themselves in the game, and offer a fantastical escape. I designed the game’s logo and repeatable elements (like the puddles and stepping stones) and used royalty-free assets from Shutterstock to build the different levels (city, forest, mars, underwater). It was important to me that the game offer both a male and female runner, and that the runners look like the participants. For these reasons, I commissioned a graphic designer to create custom runners for PuddleJump. Each character can run and jump and they are programmatically identical (i.e. the girl is not a faster runner). It took several rounds of design to get the features just right. Designing the girl avatar proved more challenging than the boy, as the girls in my participant groups are generally further along in puberty and are thus taller than many of the boys. We solved this by having the girl avatar appear to be slightly further away, thus keeping the occlusion maps identical for the two sprites.

## ***6.4 Deployment design***

The website was just one component of the StepStream system. I designed StepStream as a month-long school-based program, and this decision meant considering a host of other enabling technology, including the pedometers and base stations, as well as environment-specific constraints of working with children under 13 in a low-SES community. These considerations all impacted the system design. In this section I describe the requirements of the deployment and how this affected my system design approach.

### **6.4.1 Getting connected: Pedometers & base stations**

Participants in StepStream present an unusual set of requirements on sensor technology. I couldn’t feasibly ask 30-40 middle school children to independently set up syncing technology on their home computers, especially when a number of the children did not have reliable Internet access at home. Thus, any connectivity embedded within the pedometers



**Figure 10:** PuddleJump levels: city, forest, mars, underwater.



**Figure 11:** Fitbit pedometer used in the ‘self-tracking’ and ‘social’ deployments. The pedometer number is written on a small sticker above the screen, and the URL of the website is printed on a green strip below the screen.

had to either be cellular (e.g. a smartphone) or school-based (e.g. a base station). At the time of the studies, many students in my participant population did not have smartphones, and none had smartphones with battery-saving motion sensing capabilities. So I looked for a pedometer that could wirelessly sync with a base station I would place in the school. Connectivity presented another challenge: few wireless pedometers that work with base stations provide third-party access to the activity logs from individual pedometers. Of the few that do, only Fitbit was willing to sell pedometers in units as small as 100.

The Fitbit met most of my requirements, but the version available at the time (the original ‘clothespin’ design) was not waterproof and the pedometers prone to breaking (I had personally destroyed three in one year). Fortunately, in November 2012 Fitbit launched the Zip, a waist-mounted pedometer that runs three months on one battery charge (it uses a watch battery) and stores the last 30 days of step data. Fitbit Zips can sync with a base station when they’re within bluetooth range (about 30 feet).

### **6.4.2 Schools, IRBs, COPPA oh my**

StatusNet—the underlying technical framework for the StepStream website—was also useful for a number of reasons that apply uniquely to my deployment site and user population. In order to gain permission to deploy social software to children within the public school district, I had to promise that the system would be SSL encrypted and totally password-protected. That is, no unauthorized person would be allowed to view, let alone post, the contents of StepStream. The Georgia Tech IRB also wanted to make sure that I had control of the data at all times, so they highly suggested a self-hosted solution (that is, a solution where I can inspect the code, possibly host the server on the Georgia Tech campus, and never send personal data via a third party).

I also needed to create and own my own system, rather than deploying a plugin for—say—Facebook or Twitter, because a majority of my participants were under the age of 13. The Child Online Privacy Protection Act, or COPPA, is generally held to prohibit signing children up for public services under the age of 13. The school system explicitly forbade any school-sponsored system from connecting to a commercial social network site. Finally, the school district prohibited individual private messaging in the system, due to the heightened risk for cyberbullying, sexting or other abuse.

### **6.4.3 Designing for resource-limited environments**

The socioeconomic characteristics of my deployment environment also affected my design strategy. For example, although smartphone adoption was broad in the middle school population nationally, in the schools I worked with penetration was much lower than that—in informal polls as few as 50% of students reported regularly using a smartphone. This has since changed in at least one of the schools I worked with, but I decided to err on the side of inclusion.

I've already discussed the design implications of resource-limited environments on my pedometer choice, but it also affected the design of the StepStream website. If I were



making StepStream today, I would probably include a mobile app as a central interface. I also probably wouldn't have to make sure my site worked on Internet Explorer 6 (IE6), a browser released before many of my participants were born. But because many of the school computers still used IE6, I wanted to make sure my site would load and still look good on that browser. Fortunately I was able to use a simple JavaScript library called CSS3PIE (<http://www.css3pie.com>) that simulates modern web layout techniques for antiquated browsers.

Connectivity reared its head one final time: connecting the base stations *themselves* to the Internet. This requirement had been a major barrier for some schools in the AHPC, since the base stations relied on stable Internet access through the school's system in order to transmit steps to the program website, just like StepStream. The Internet access was unreliable at the schools I worked with, and although the schools had wifi, its use was prohibited. The CTO of the school district flatly refused to allow my base station to use the school's Internet connection.

I decided a technical end-run would be prudent, so my base station (a generic PC running the Fitbit sync program) connected to the Internet using a WiMax connection. WiMax, a '4G' wireless Internet protocol, allowed my base station to connect to the Internet as long as it had line of sight to the outdoors, without relying on the school's connection. I also installed a 'heartbeat' application on the base station so I could check its status remotely.

## CHAPTER VII

### ‘SOCIAL’ DEPLOYMENT STUDY

In the spring of 2013, I conducted a month-long ‘social’ deployment of StepStream with 42 students in a public middle school. In this study, I show how participants improved their attitudes about fitness and increased their sense of social support for fitness. The least-active students also increased their daily activity. I show evidence that my school-based social fitness approach performed comparably in attitude and behavior change to more competitive or direct-comparison systems.

#### **7.1 *System***

In this study, I deployed the ‘social’ version of StepStream. Students wore Fitbit Zip pedometers, and used the ‘social’ version of the StepStream website, where they could see their own progress and interact with each other by posting, commenting, and playing a game. The pedometers wirelessly uploaded students’ daily step counts to the StepStream website via a base station (generic PC + WiMax connection) located in the school security office next to the main entrance. For more information about the system design, please see Chapter 6.

#### **7.2 *Method***

I have employed a variety of methods to understand students’ preferences and reactions with respect to social systems for fitness, ending with a month-long deployment of the StepStream system. Along the way I have collected and analyzed design concepts, system usage logs, focus groups and interviews.

Weekly after-school meetings were a key part of the system design, and directly inspired by our formative work. The strongest theme to emerge from our formative work was

students' desire for 'social presence' the sense that their friends and classmates would be available to play and chat. Students in our formative studies told us repeatedly how much they valued live interaction and the sense that their friends and classmates were present in a social health system [56]. Through regular meetings during the deployment, I sought to encourage students to blend the StepStream website into their offline social interactions, giving students time and space for indirect comparison and observational learning with fitness as the backdrop.

### **7.2.1 Participants**

Forty two (42) students participated in the study. Students were demographically representative of the school as a whole: 45% male (school: 53%), 55% female (school: 47%), 76% African American (school: 69%), 10% Hispanic (school: 9%), 14% Asian (school: 7%). The median age for participating students was 13, and most students were in the 6th and 7th grade. These surveys used standard US Census terms for race/ethnicity (see appendix for exact wording). Although I didn't collect income information from the students themselves, 72% of students at the school qualify for free or reduced meals from the Title I program, a US federal meal assistance program targeted at children in low-income households.

Students in this study attend the same school as those from the 'prototype' deployment study, and the teachers and administrators involved in this study also worked on that study. 14 students in this study previously participated in the 'prototype' deployment.

Based on self-report, students in the study are not significantly more overweight than national averages (about 1 in 3 American adolescents is overweight or obese). Thirteen students (31%) qualified as overweight (greater than 1 standard deviation above average) [16]. However, the students in our study face higher than average risks of becoming overweight or obese. They live in a majority-minority low-income medium-density urban community with low walkability (similar to the students in the 'self tracking' deployment).

Students' Internet and social media use mirrored national averages. Students reported going online an average of 2.65 hours per day, and all but two students regularly accessed the Internet from home. For comparison, the 2011 Pew Online Teen Demographic survey reported that 92% of 12-13 year olds go online [63].

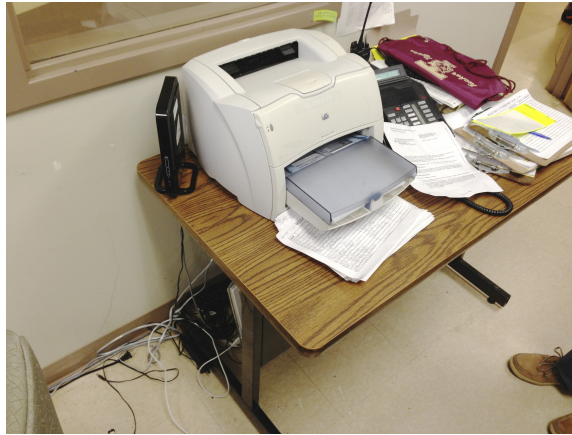
### **7.2.2 Deployment**

I conducted a four-week deployment of the StepStream system in Spring 2013. I met with students as part of an after-school program once a week, for a total of five meetings. Before the first meeting, I set up a base station (a PC located in the school security office with a dedicated WiMax connection) and created accounts for each pedometer. Each time students walked past the base station, the pedometers uploaded their steps.

#### *7.2.2.1 Preparation & setup*

I worked with the four teachers who participated in the 'prototype' deployment study, and in particular I coordinated with the school's Family and Consumer Sciences (FCS) teacher. This teacher, whom I met through recommendation by the school district's research department, worked with the other teachers to recruit potential participating students. Teachers selected students whom they felt would be responsible and interested in the topic, but at my request did not favor physically active students. I directed them to select a representative cross-section of the school.

I met with the teachers three times before beginning the deployment, and stayed in constant phone, text and email contact with the FCS teacher. I also spoke with the school principal and the school's security officers, who allowed me to place the StepStream base station in their office. This location was ideal because it allowed me to secure the technology near a high-traffic area of the school, and it had line-of-sight access to the outdoors for the WiMax antenna. However the base station did face some difficulties in this school. The school's power supply is unreliable and subject to brownouts, where the voltage drops



**Figure 12:** Base station located underneath the printer desk, with WiMax antenna.

unexpectedly. Due to the brownouts, I had to make 3 unscheduled trips to the school to re-set the base station. I also discovered—after some fairly extensive troubleshooting—that when the microwave in the security office was on the WiMax connection would cut out.

#### *7.2.2.2 After-school meetings*

In partnership with the deployment school, I created an official after-school program held immediately after school for one hour a week during the course of the deployment. One teacher was present at each meeting as a representative of the school, but did not engage in the research activity and generally sat in the back of the room grading papers. This weekly after-school structure served as a familiar template for the students, teachers and administration, and gave us the ability to check in with students throughout the deployment.

In the first meeting (held in a classroom in the school), I conducted pre-intervention surveys and distributed pedometers. I showed students how to wear the pedometers and then took them to see the base station (located in the security office at the school entrance) and instructed them to walk past it at least once per day. During the first week, I collected students' pedometer data from the base station but did not give them access to the system website, so I could establish baseline activity levels and give students a chance to get used to the pedometers. On the day before the second meeting, I created a baseline average daily step count for each student. I took the mean of their daily step counts for days where they

recorded more than 1,000 steps. This allowed me to set a personalized baseline for each student.

In the second meeting, I met the students in the school computer lab and gave students access to the website. Students logged in and I showed them the various features of the site. This introduction lasted about 15 minutes, after which students were free to use the system, chat and hang out for the remainder of the hour. I reset and replaced any malfunctioning or lost pedometers, and walked around answering questions. I also held the third and fourth meetings in the computer lab, giving students time to interact with the system and report broken or lost pedometers. In these meetings, students generally gathered in four to five clusters and then logged into the site. The computer lab had five rows of 10 computers each, so students were able to sit near friends and chat. I spent the bulk of these meetings replacing pedometers and resetting passwords for students.

In the final meeting, students took a post-intervention survey and I conducted a focus group to talk about their experiences during the deployment. Several weeks later, I met with students again and conducted three smaller focus groups with 8-10 students each.

### ***7.3 Data collection & analysis***

I evaluated StepStream in several ways: through pre/post surveys, focus groups, log data analysis of participants' interactions on StepStream, and step data analysis.

#### ***7.3.0.3 Surveys***

Pre/post surveys (similar to prototype deployment, but without PEAQ questions and with the addition of questions about StepStream itself in the post survey)

#### ***7.3.0.4 Log data & step data***

I also collected log data from the system including logins; articulated friend relationships and their changes over time; posting; even lurking. I qualitatively analyzed students' messages using an iterative coding method where two researchers independently coded each

message, then agreed on a common set of codes, and then independently coded a second time with the common code set. I also performed descriptive quantitative analysis of logins and message frequency.

As in my ‘self-tracking’ study, I focused on a sub-group that was half the size of my participant population. This re-affirms best practices from previous pedometer studies and confirms others’ experience of the ‘noisiness’ of step data in field deployments [48, 73].

In the ‘social’ study, I concentrated on a sub-sample of 21 students who ended the study with sufficient baseline and post-baseline data for analysis (that is, they had four or more step days in the baseline week and 12 or more step days over the rest of the challenge, following best practices from the youth pedometer literature [73]). Students in our sub-sample mirrored the participant pool in all ways I could measure, including average BMI (6 [29%] overweight), ethnicity (16 [76%] African American, 2[10%] Hispanic, 3[14%] Asian), gender (9 male [43%], 12 female [57%]) and average age (12.5). Critically, our sub-sample did not appear to be more active: average steps per day for the sub-sample (6408) were almost identical to the overall average (6481).

As with the ‘self-tracking’ study, I analyzed students’ average steps per day and imputed missing data using the baseline average. I then performed repeated-measures ANOVA tests for significance [73].

#### *7.3.0.5 Focus groups*

After the deployment concluded, I conducted four focus groups: one with all participants, and three with smaller groups of 8-10 students each. These focus groups incorporated the same questions about StepStream and offline physical activity as the ‘self-tracking’ deployment, but I also asked about the social aspects of the system.

### **7.4 Findings**

StepStream users reported increased enjoyment of physical activity and increased peer support for fitness. Students used StepStream within and between our after-school meetings,

and exercised regularly throughout the deployment. Students enjoyed the game, but played it less often than I had hoped. I also saw indications that participants with lower initial activity levels made the most improvement in step counts over the course of the deployment. In this section, I report the results of our surveys, focus groups, and log data analysis.

#### **7.4.1 Improved attitudes & social support**

Since health behavior change theories all focus on attitude change as a prerequisite to sustained behavior change, I was particularly interested to see how StepStream may have influenced students' perceptions of their own abilities, comparison to other students, and fitness in general.

Overall, the results from the surveys were encouraging. Compared to a pre-deployment survey, StepStream users reported increased enjoyment of physical activity ( $Z=-1.89$ ,  $p<.05$ ,  $r=.67$ ). Social support indicators were also encouraging: overall, students were more likely to think of their friends as partners in their everyday fitness. Students reported greater encouragement for physical activity from friends ( $Z=-1.92$ ,  $p<.05$ ,  $r=-.46$ ). I asked about peer social support in the focus groups and free-response section of the survey as well, and students shared a variety of ways this social support manifested. One typical such response came from a student who told us “My mom bought a pedometer and we walked together.” Another shared “Sometimes when you walk with your friends it’s like more fun than doing it yourself.”

Students also reported feeling a greater sense of fitness expertise as a result of StepStream. Compared to the pre-study survey, students in the post-study survey reported that friends were more likely to ask them for ideas on how to get exercise ( $t(25)=2.45$ ,  $p=.02$  (1-tailed)). Participants were also more likely to talk about how much they like to exercise ( $t(25)=2.22$ ,  $p=0.04$ , (1-tailed)). One student even reported being mildly chastised for her enthusiasm: [eventually] “my teachers and family and friends were like stop [talking about



pedometer fitness].” Another student told us that he valued the ability to connect with others similarly interested in fitness. “It’s a great way to connect with other people who like to exercise and communicate.”

I saw no statistically significant changes in more deep-seated or long-term attitudes, such as participants’ perceptions of their own abilities in sports they currently play, their abilities in other organized physical activities such as PE class, or their self-reported time engaging in sports. It is also possible that some of the increase in students’ interest and enthusiasm could be attributable to participating in a pedometer trial itself.

However, the changes I did see were encouraging. Adolescents’ attitudes to social support for fitness are difficult to change, and statistically significant improvements in these attitudes do not always occur, even in otherwise successful systems [48]. In the AHPC, for example, students’ reported levels of fitness enjoyment did not increase, and while students reported increased social support from teachers, social support from friends and parents stayed the same [29].

#### **7.4.2 Increased step counts for least active**

StepStream appeared to help those most in need of elevated fitness levels: those whose initial baselines were below the group average. I found a moderate negative correlation between improvement over baseline and starting baseline (Pearson’s  $R$  of -0.6). The overall trend for all subjects was modest. Students averaged 6137 steps/day in the baseline period and 6465 steps/day while using StepStream, but the difference was not statistically significant. However students whose initial baselines were below the group average (the lower 50%) improved their daily step counts by an average of 1,088 steps/day while using StepStream (repeated measures ANOVA,  $p=.02$ ). Similar improvements have been seen in adolescent pedometer programs in the health promotion literature; in these studies, an increase of more than 1,000 steps/day is considered significant, when combined with improvements

in psychosocial indicators. It is also common for these studies to show significant improvement for lower activity youth with only modest improvements overall [48]. In our previous work, students in the AHPC improved their daily step counts by 828 steps compared to baseline, and the lower 50% improved their daily step counts by 1364 steps/day [29].

#### **7.4.3 Website use and the social stream**

The social stream in StepStream was an even mix of social discussion, physical activity posts and gameplay reports. A total of 502 posts were generated during the deployment. Students could create free-form public messages in the website using a prompt box at the top of the page, and the system also generated posts when students played a game, marked each other as friends, and when students had an above average step count. Students wrote 187 (37%) messages, played 186 (37%) games, and StepStream generated 129 (26%) system notices.

Students used the website the most during the after-school meetings. Students logged in 232 times, and the average student logged in 5 times. 65% of logins occurred during the meetings, and 35% of logins occurred between meetings. System use followed a consistent pattern during the course of the deployment. For example, 39 users logged in to StepStream on the day of the first meeting, and 30 on each of the subsequent meeting days. Meeting days also saw the highest non-meeting logins: 7 each, compared to an average of 3 non-meeting logins per day overall.

Web site activity continued regularly through each meeting. Students sent an average of 7 messages per minute during these meetings, peaking at 9 messages per minute about 40 minutes in. I gave no additional instructions during the meetings, and students could easily have logged in once and then abandoned the system for the rest of the hour. I therefore interpret students' messaging activity as an indication of interest beyond doing what they were told.

As expected, some students posted messages about health. These messages took the form of advice and encouragement for fitness (e.g. “BRING YOUR PEDOMETER WITH YOU EVERYWHERE YOU GO!”), or public commitments (e.g. “I’m going to walk around to stay FULLY ACTIVE!!!!”). 1 in 10 messages was health-related.

However, a majority of the messages in StepStream were primarily phatic in nature, that is they conveyed little ‘content’ but were instead intended for social grooming, identity presentation or emotion display. Many messages were variants on ‘welcome’ such as “HI ^ ^”, “HI THERE! :)”, “wazz up my people” or “hey everybody”. Although they peaked in the first session, these ‘welcome’ messages continued throughout the study. 1 out of every 3 messages was a ‘welcome’ message. In addition to the ‘welcome’ messages, I saw everything from ‘nonsense’ messages (e.g. “JKYZSCY7TSFGTVSCY”) to messages that were just another user’s username. I also saw evidence of inter-personal statements in the stream. For example, some students even tried to start rumors of a relationship between two other students.

#### **7.4.4 StepStream beyond the classroom**

I also looked at the pedometers as physical manifestations of the StepStream system. Students took their pedometers (and thus a piece of StepStream) with them everywhere they went. In our observations and focus group discussions, students reported being emotionally attached to their pedometers. Upon entering the computer lab for the weekly meetings, I was often met with a short line of students with devastated faces, apologizing for having lost their pedometers. Overall, about half of the students in the deployment lost their pedometer at one point. This was partly due to the nature of pedometer deployments; any youth-focused pedometer deployment will result in substantial pedometer loss.

Students wore their pedometers in some surprising places. For example, 11 students reported wearing their pedometer in the shower, and several accidentally put the pedometer through the wash. 14 students even wore the pedometer to bed. One student told us “I went

to bed and when I woke up I had like 112 steps. And I was like ‘I sleepwalk!’” Another student kept her pedometer close at hand during the night “It was like the middle of the night and I needed to go to the bathroom, so I put it on to get steps. So I went to sleep and then I woke up and it was on.”

#### **7.4.5 Gameplay**

Gameplay was the one area in which StepStream performed below our expectations. While students played PuddleJump throughout the challenge (that is, there was no steep drop-off or measurable decline in usage across the deployment), gameplay mainly took place during the in-person meetings. Overall, 70% of games were played during the meetings. Students played the game an average of 5 times each over the course of the deployment. Students also used the social aspect of the game: they had the option of choosing up to three friends to play with, and after the first day, all gameplay sessions were ‘with’ at least one other user. However, I designed the game to be played two to three times per week; I hoped to extend the social presence of the in-person meetings into asynchronous, daily use. While students enjoyed playing the game, they seemed to prefer not to play it when others were not around (that is, between meetings). This result was disappointing because I was counting on the game to generate a sense of collective efficacy outside of the weekly meetings and to act as a light incentive to wear the pedometer daily (since students could only play the game if they had walked enough steps). Fortunately, (as described in the next section) the meetings themselves became important events for establishing collective norms.

This result may be due in part to students’ persistent desire for live interaction. I knew from formative work that participating students would value live interaction and that the social presence of their peers would play a key role in the system’s success [56]. This preference for live interaction is reflected in our focus group discussions and surveys as students told us they wanted their friends to be in the game with them live, and in person if possible. Students may also simply have tired of the game; I am not a professional

game designer or game researcher, so the game itself was merely designed to be “good enough” to act as a diversion and give students another reason to log in between meetings. I based the game’s design on similar games created by students in my participatory design studies (and on popular commercial games such as Jetpack Joyride and Temple Run), but one simple game may never have been enough to generate significant interest on its own. In focus groups and surveys, many students told us they wanted to see a greater variety of games in future versions of the system.

## **7.5 Discussion**

Overall, our study results provide evidence that the combination of the social StepStream website, pedometers and regular after-school meetings created a system that allowed students to socialize around fitness. Our study also raises interesting questions about school-based social fitness systems for youth, particularly around the social support mechanisms at work, the in-person component of the deployment, and the promise of “hanging out” as a strategy for sustained long-term use.

### **7.5.1 Social support & observational learning in StepStream**

Users of StepStream reported higher levels of peer social support for fitness after using StepStream. I suspect a combination of features within StepStream itself may have impacted students’ sense of peer social support. There were at least two features of the website designed to generate this sense of peer support: automated congratulations and gameplay success messages. Students who logged into StepStream were likely to see a mix of messages from other students, congratulatory messages for other students, and successful gameplay sessions. I suspect that this combination of real messages and physical activity reports created the feeling that students were hanging out around fitness, if not actually talking about fitness. Students’ messages made the site feel alive, and the gameplay and step achievement posts weaved in health-focused content.

This in-person social support complemented social support occurring outside the schools. In our surveys and focus groups, students told us they made time to exercise together and talked about the system with each other on occasion. However, offline discussion alone was unlikely to be responsible for the level of change in social support I observed with StepStream. For comparison, in the AHPC—which relied almost exclusively on offline means of social support—students reported little improvement in peer social support [29].

In the StepStream website, I directly observed examples of esteem support. Most of the health-related posts in the system were of this type: students encouraging each other to get more physical activity through direct posts in the stream. For example, one student wrote “Keep walking alot!!”. I also saw some examples of informational support, in which students provided tips or strategies for increased physical activity. These were not usually particularly specific, but students did offer advice such as “Remember to take your pedometer with you everywhere you go!”. More intriguing is the social support not recordable by system logs: companionate social support (in which people join each other for exercise). Students reported in the post-study focus groups and interviews that they engaged in these activities, telling me of many occasions where they walked with friends and family.

Taken together, the social support implications of StepStream are heartening; students can be reluctant to talk about health topics, and a system that can engage them without forcing artificial discussions may prove more sustainable in the long term.

### **7.5.2 The role of playing**

I intended the PuddleJump game to serve several purposes: to give students a light incentive to log in, to serve as a collective ‘common ground’ for collective achievement, to give students something fun to do in the system besides chat, and to give students a sense of ‘social presence’ when their friends were not with them live. The PuddleJump game was also designed based on ideas from my formative design exercises, so I knew it was a style

of game the students were interested in. However, the game ended up presenting as many challenges as opportunities.

Overall, students reported enjoying the game. However they didn't use it as frequently as I had hoped, and most of their suggestions for how to improve StepStream related to ways to improve the game. The most frequent suggested improvement was access to a virtual arcade where students could play many games, not just one. This is at once a good sign (students didn't appear to actively dislike the game!) and a cautionary one: participating students were highly familiar with games and gameplay, and their expectations were therefore quite high when it came to evaluating a game, even within a novel context such as StepStream.

The presence of a game also complicates my analysis of StepStream. It's unclear how much of an effect the game had, and whether students' interest in playing the game was due merely to an incentives mismatch or to that particular game not being the right fit for the system. The game may not have presented the right kind of challenge or 'stickiness' to players. All these factors are important to understanding the game and none of them lie directly within my capability as someone who does not primarily study games.

On a more practical level, the inclusion of a game in StepStream confused reviewers and colleagues about the purpose of StepStream. My CHI paper about the 'social' deployment was even lumped into an "exergaming" session, despite StepStream being decidedly not an exergame. In the end, if I were deploying StepStream a second time, I would try it without the game, or at least create another condition where students had access to the social features of StepStream but did not play a game.

### **7.5.3 Meetings as digital events**

To the extent that StepStream improved students' sense of social support and attitudes towards fitness, it seems to have done so because of the school-based meetings and students' time together. While students engaged with the system daily by wearing a pedometer, about

two thirds of website logins occurred during the three weekly one-hour after-school meetings held in the school's computer lab. I designed these meetings to primarily be check-in sessions, where students could log in and check their steps, share a tip about how to get steps or an encouraging note, and seek help with pedometer replacements or repair. But in the course of the deployment, I came to realize the meetings had a more significant role: as digital events and catalysts for blending online and offline social interaction, with fitness as a backdrop.

The meetings occurred right after school, and students arrived energized and ready to socialize. Although I was not able to observe every conversation, the general topic of these conversations was often anything but health. Mainly, the meetings seemed to serve as a space to “hang out” with friends and classmates, with fitness in the background. That students would use a social system for this grooming, chatting and play makes sense—hanging out is what adolescents do online [10].

However, StepStream was an important and constant backdrop in these meetings. Most students left StepStream open for the whole hour, checking in with the social stream. They posted messages and played games throughout the meetings. Students would break to chat with each other, then look back at StepStream and post or play another game. Students were more than simply attending a meeting, or sitting alone together glued to their screens. If anything, during the meetings students were *together* together: hanging out in small groups throughout the computer lab while monitoring and responding to the social stream.

#### **7.5.4 “Hanging out” as a self-sustaining strategy**

If adolescents adopt a social health system into their normal “hanging out” behaviors, such systems have the potential to shape those interactions and foster new norms. This is a delicate process: StepStream took a light touch, advocating personal improvement and discouraging competition. It's possible that a more proscriptive or overtly curricular approach



might be rejected, but when done appropriately, these sorts of ‘digital events’ hold great promise for youth-focused social health deployments.

In carving out a blended online/offline space with fitness as the backdrop, StepStream appeared to foster a ‘new norm’ around fitness, and targeted opportunities for observational learning. Students observed each other playing the game, hanging out in the fitness system, and being congratulated for getting steps and internalized this. While hanging out together, students undoubtedly engaged in social comparison, but without leaderboards or step counts, their opportunities for competition were (purposely) reduced. Additionally, StepStream appeared to avoid the initial novelty effect often associated with the introduction of a new technology, in which participant interest in the system wears off and activity slows. Within the study period, I saw little evidence of such a novelty effect (such as a drop in logins, messages or meeting attendance). Sustaining middle school students’ interest over even a month-long program can be challenging. However, structuring our deployment as an after-school program allowed students to periodically re-connect, and allowing students to hang out without ‘doing work’ within the meetings may be a key reason for students’ continued engagement through the end of the deployment.

#### **7.5.5 Theory meets reality**

StepStream shows the promise of a social computing approach to make important attitude and perception changes in the short term. I designed the ‘social’ system to encourage peer social support and observational learning effects without relying on direct social comparison or competition, and this produced encouraging increases in key attitude, social support and physical activity measures. By letting adolescents ‘hang out’ around fitness without proscribed ‘top-down’ motivational techniques, I provided opportunities for observational learning effects.

However, a month-long study is not long enough to show true health behavior change or to encounter longer-term novelty effects. Students’ self-efficacy for fitness remained

largely unchanged, and providing a non-competitive sense of collective efficacy (through the game) provided more challenging than I'd anticipated.

Still, this study shows that a blended online/offline social approach to adolescent fitness offers an encouraging model for others, and a valuable lesson for longer-term studies.

## CHAPTER VIII

### **‘SELF-TRACKING’ DEPLOYMENT STUDY**

I conducted two full deployments of StepStream: a ‘self-tracking’ deployment at one school—reported in this chapter—and a ‘social’ deployment at another school, described in the previous chapter. The ‘self-tracking’ deployment represents a contrast to both the ‘prototype’ and ‘social’ deployments—a different school and a different feature set—while maintaining several common elements, such as the underlying technology platform and general participant demographics.

I wanted to see how much impact a self-tracking system would have on students’ attitudes and behaviors—without the competition mechanic used by the AHPC, and without the social awareness mechanic used in other StepStream deployments. Without the system prompting them to socialize around health, would they supplant that with offline discussion? And without deliberately persuasive features (such as prizes and badges) would they maintain or increase their activity levels throughout the deployment? Through observing StepStream in a different configuration, I also sought a deeper understanding of the influencing factors in school-based pervasive health programs.

In this chapter, I describe findings from a deployment of a self-tracking pervasive fitness system for adolescents. Overall, students in this study did not improve their attitudes about health and fitness, and there was no overall increase in daily physical activity. However, my study of the ‘self-tracking’ version of StepStream with this particular population proved instructive. I provide evidence that two contributing factors were salient with respect to outcomes: the specific social structure of the participant group, and the persuasive design of the system. I argue that the lack of change in attitudes or behavior indicates that even a group with strong social ties will not necessarily leverage those connections

for fitness without encouragement from the system. This study also provides evidence that attitude and behavior change seen in other deployments (especially the ‘social’ version of StepStream) are also due to these factors, and not merely the result of novelty effects or researcher bias. I also argue that designing for existing groups may be beneficial, and describe design challenges for this population.

## **8.1 *System***

In this study, I deployed the ‘self-tracking’ version of StepStream. Students wore Fitbit Zip pedometers, and used the ‘self-tracking’ version of the StepStream website, where they could see their own progress but not interact with each other online. The pedometers wirelessly uploaded students’ daily step counts to the StepStream website via a base station (generic PC + WiMax connection) located in a classroom in the school. For more information about the system design, please see Chapter 6.

## **8.2 *Method***

I worked with the school district to identify candidate schools, then worked with a teacher at the chosen school to recruit participants and schedule meetings. I conducted a four-week deployment with 12 Atlanta-area middle school students during the months of March and April 2013. Students wore pedometers for one week without using the website, then wore pedometers and used the website for three following weeks.

### **8.2.1 *Participants***

Twelve students participated in the study. Four boys and eight girls participated (school average: male 53%, female 47%). All students were African American (school: 98%). The median age for participating students was 13.5, and all students were in the 7th and 8th grade. Although we didn’t collect income information from the students themselves, 85% of students at the school qualify for free or reduced meals from the Title I program, a US federal meal assistance program targeted at children in low-income households.

Students were more overweight than average: 9 students self-reported BMIs (age-adjusted height-weight ratio) that qualified them as overweight or obese. The national average is about 33% for adolescents [45]. Additionally, significant race-correlated health disparities exist in their local community; for example, in 2010 68% of Black or African American adults in the county were overweight or obese, compared with 52% of White adults. [38] Additionally, both lower-income and minority households report feeling significantly less safe walking around their neighborhoods, a statistic often correlated with higher rates of obesity [75].

Students' Internet and social media use mirrored national averages. Students reported going online an average of 3.5 hours per day, and all students regularly accessed the Internet from home. For comparison, the 2011 Pew Online Teen Demographic survey reported that 92% of 12-13 year olds go online [63].

### **8.2.2 Deployment**

I conducted a four-week deployment of the 'self-tracking' StepStream system in Spring 2013. I met with students as part of an after-school program. Students wore pedometers for one week without using the website, then were given access to the website for the remaining three weeks. A base station located under the teacher's desk transmitted students' step activity to the StepStream website when they walked within 20 feet of the classroom.

#### *8.2.2.1 Preparation*

I recruited students through an existing after-school club (the Family, Career and Community Leaders of America, or FCCLA). Students in the club complete 'family and consumer sciences' (FCS) projects in their school or community, and then document those projects and submit them to county, state and national competitions. 'Family and consumer science' is a discipline that grew out of 'home economics' and encompasses varied content such as nutrition and cooking, budget management, parenting and fashion design

(<http://www.aafcs.org/>). In the school district with which I work, FCS teachers are supervised both by their principal and by a district-wide Career, Technical & Agricultural Education department. This department connected me with the target school's FCS teacher, and she helped me recruit students in the FCCLA club.

#### 8.2.2.2 *After-school Meetings*

Over the course of the deployment, I met with participating students three times:

1. A week before the official start of the deployment I attended a club meeting to distribute consent forms, explain the program, and test the base station
2. At the official start of the deployment I met with students to hand out pedometers, sign them up for StepStream, distribute surveys, and test the base station again
3. At the official end of the deployment I met with students to collect pedometers, distribute surveys, conduct a focus group, and remove study equipment

A student assistant accompanied me on the first two of these visits, assisting with technical setup and helping students create their accounts on the StepStream website.

I intended to conduct five meetings, one per week. However, the students were attending a state-wide FCCLA conference during the second week of the deployment, and the third week of the deployment included a furlough day (on which teachers take unpaid leave and students do not attend school) on the scheduled meeting day of the third week. As the students had other after-school activities on other days of the week, it proved impractical to re-schedule the meetings. I maintained regular text-message contact with the FCS teacher, but was unable to conduct interim meetings with participating students during the deployment. I logged in daily to check system status, and I added a new 'level' to PuddleJump weekly.

One other unexpected challenge was connecting the base station to the Internet. I originally asked the FCS teacher if I could place the base station in the school's security office,



**Figure 13:** WiMax modem (black box) with booster antenna (white slab behind modem).

but she told me she did not feel comfortable doing this and would much prefer to have physical oversight of the computer herself. I therefore placed the base station in the classroom under her desk. However, the FCS classroom in this school was in the center of the building, with no line of sight to the outdoors. I was able to get the connection working after purchasing a booster antenna (shown in Figure 13).

### **8.2.3 Data collection & analysis**

I evaluated the ‘self-tracking’ version of StepStream in several ways: through pre/post surveys, focus groups, log data analysis of participants’ interactions on StepStream, and step data analysis.

#### *8.2.3.1 Surveys*

I surveyed participating students on their attitudes and perceptions to physical fitness, using a modified version of the survey from my formative ‘prototype’ deployment. For this study, I removed the ‘PEAQ’ questions that asked about StepStream as a personally expressive identity activity. These questions had been relatively unhelpful to me in the formative deployment and took up a substantial amount of survey time. I added new questions about students’ social media activity, taken from the Pew Internet and American Life project [46]. These surveys allowed me to get a quick snapshot of students’ online activity, in case my

population was abnormal in this respect. I also added a section about StepStream to the end of the post-study survey. These questions served both as individual responses and as fodder for the focus group. I adapted these questions from the interview prompts I helped develop for the AHPC. The full survey is available in the Appendix. I compared the pre and post study surveys using the Wilcoxon signed rank test, however the total participant number in this study was too low to assess significance using this measure, so I also used a paired T-test.

#### *8.2.3.2 Focus group*

After the deployment concluded, I conducted a focus group with all participants. In the focus group, I sought to understand whether or how StepStream changed the way students think and talk about health and fitness, and to better understand how they fit the deployment into their daily lives. I focused on gathering students' individual experiences of StepStream, and probed them to tell us about their use of the system outside of the weekly meetings. I concluded by asking students what they would change about StepStream.

#### *8.2.3.3 Log data & step data*

I collected login and gameplay data from the system, to see when participants used the StepStream website and when they played a game, and collected step data recorded by their pedometers and uploaded to StepStream. To analyze students' step data, I concentrated on a sub-sample of 5 students who ended the study with sufficient baseline and post-baseline data for analysis (that is, they had four or more step days in the baseline week and 12 or more step days over the rest of the challenge, following best practices from the youth pedometer literature [73]).

The 5 students in my sub-sample were representative of the 10 students who participated in the study. I looked at several indicators for comparison, including average BMI (5 [83%] overweight), ethnicity (5 [100%] African American), gender (5 female [83%], 1 male [17%]) and average age (13.5). The sub-sample was slightly more active than the



whole: students in the sub-sample (5726 steps/day) walked just under 300 more steps per day than the overall average (5437 steps/day). However, differences of under 300 steps per day are not considered significant in pedometer research [48].

The in-the-wild nature of school-based fitness deployments means students may often lose or forget to wear their pedometers on certain days, and focusing on a sub-sample with more robust step count data is a common procedure in youth-focused pedometer-based deployments [48, 73]. For example, in the AHPC only 66% of students qualified for step data analysis [29].

I analyzed students' average steps per day, looking for overall improvement and correlations with other variables, such as baseline steps per day. Following best practices from the physical activity literature [73], I imputed missing data using the baseline average (that is, assuming no change post-baseline) and performed repeated-measures ANOVA tests for significance [73].

### **8.3 *Findings: surveys & data logs***

There was no statistically significant increase in attitudes and perceptions of fitness, and participants did not increase their daily step-counts. However, the study did generate interesting findings about the effects of the existing social structures and strong social ties in the participant population, and the effect of students' competitive attitude on system use.

#### **8.3.1 Attitudes & social support**

Students' attitudes about fitness, self-reported time engaging in fitness activities, and enjoyment of physical activity were unchanged after using StepStream. Their sense of social support for fitness actually declined slightly on two measures: how likely they were to exercise together [ $t(12)=1.95$ ,  $p_i.05$ ] and how likely they were to *offer* to exercise with friends [ $t(12)=2.12$ ,  $p_i.05$ ]. Participants also reported being less likely to get rewards for exercise [ $t(12)=2.83$ ,  $p_i.05$ ].

### **8.3.2 Step counts**

Participants did not statistically significantly improve their daily average step counts during the deployment. Participants walked an average of 5238 steps/day during the baseline week and 5822 steps/day during the three following weeks, but with a p-value of 0.12 this result was not statistically significant.

### **8.3.3 Website use & gameplay**

Students used the website throughout the deployment; all students logged into StepStream at least twice. Users logged in an average of 4 times (just over once per week) and no user logged in more than 6 times. Logins were spread fairly evenly across the deployment, with one peak of 9 logins on the day of the final meeting. Six students played PuddleJump; each played an average of two games.

### **8.3.4 Findings: observation & interviews**

On their own, the findings from my surveys and data logs are relatively uninformative. But when combined with my observations and interviews, they help paint a more complete picture of StepStream and the potential opportunities and challenges for pervasive health applications for adolescents. I highlight two particularly salient factors: the social ‘closeness’ of the participant group, and their achievement orientation as a competitive ‘team’.

#### *8.3.4.1 A close-knit group*

In all my prior work, and the two other studies described in this dissertation, I have studied groups of adolescents brought together for the purpose of the research. In the AHPC, schools often held lotteries for participation; in my own formative studies, teachers and principals worked together to select an applicant pool, then accepted candidates on a first-come-first-serve basis. However, the participants in this study were all part of a small, close-knit after-school club, altering the social dynamics of the deployment. These students were quite obviously ‘strong ties’: they knew each other by first name, chatted about

many topics during our meetings, and generally behaved as a group of friends would. For example, during my first visit, while my student assistant and I troubleshooted the WiMax connection, the students remained sitting around a central table in the classroom, gossiping and chatting about the events of the schoolday. The technology was more closely tied to this group than to the school as well: the base station was located in the teacher's classroom rather than the school's security office.

#### 8.3.4.2 *Competition and awareness*

From the beginning, the students and their teacher were interested in competition. all participants went on a field trip during the deployment (to attended a conference together), just them and the teacher representing their school. They stayed overnight and some of the participants presented their projects in a statewide competition. The teacher tried several times—in my presence—to describe the 'self-tracking' deployment as a competition, and each time I gently corrected her. I began to feel that this group might benefit more from the competitive school spirit framework offered by AHPC. In the end, in order to quell the competition talk, I promised to let the students know who had improved the most relative to his or her own baseline—but only after they had filled out the post-study survey.

However, this competitive interest did not appear to lead to more *awareness* of each other's activity. During the two meetings in which I observed students using the system, they would walk over to another student's computer and check to see the user's nickname and avatar and then try to assess which of them was getting more steps. However, these conversations did not appear to lead to further discussion or awareness of each others' activity, as evidenced by the flat social support survey ratings.

Students' lack of mutual awareness (with respect to physical activity) also became apparent in the post-study focus group. When I asked the students what they did to get steps, several students reported one of their biggest walking days as a group had been the day they were all together on a field trip. But when I looked at the step average for that day, it

was no more active than any other day. I actually had to double-check the dates of the field trip to make sure.

## **8.4 *Findings: contributing factors***

Fundamentally, the ‘self-tracking’ deployment shows that deploying a pervasive fitness system to adolescents does not necessarily lead to improvements in attitudes and performance. This is encouraging; it means that any improvements seen in other deployments of StepStream do not come solely or even predominantly from novelty effects or excitement about participating in a high-tech deployment. As with any ecologically valid study, there are a number of contributing factors at play. Participants’ attitudes, social connectedness, and willingness to engage; in-person meetings; and absence of persuasive design features all played a role in affecting the outcomes of the study. After surveying possible contributing factors, I found only two with the potential to meaningfully contribute to study outcomes: the social dynamics of the participant group and the design of the ‘self-tracking’ system.

### **8.4.1 Initial attitudes & behavior**

Participating students’ initial attitudes towards fitness and sports were not that different than students in other StepStream deployments. For example, ‘self-tracking’ participants’ average initial self-reported enjoyment of activity was 3.3/5, whereas ‘social’ participants’ initial average was 3.1/5. These specific numbers are merely illustrative; the broader point remains that students were neither ‘maxing out’ the survey instruments nor too pessimistic about their ability to increase their daily physical activity. Students’ average step counts were slightly lower than those of students in the ‘social’ study (5726 steps per day, compared to 6408 steps per day for the social group), but given the similarity in the two populations’ attitudes towards fitness there is no reason to believe this factor would inhibit activity improvement. Indeed, students with lower baseline step counts in the ‘social’ study actually increased their daily averages more than those with higher baseline step counts.

#### **8.4.2 Social dynamics & willingness to engage**

Participants in the study had a strong social cohesion prior to engaging in the research, and met frequently throughout the year. And yet their strong ties did not lead to an increase in social support for fitness, and observational learning of new fitness behaviors did not appear to occur either. This finding is somewhat surprising, because these students appeared to have high levels of mutual peer support in other facets of their lives, especially their club's projects and activities. Intuitively, one might assume that strong social bonds would naturally extend to fitness when given the opportunity.

I also tried to understand students' willingness to engage with the program and the StepStream system. It is possible that students were not affected by the system because they were uninterested, but I saw few signs of disengagement during the study. The indicators I can measure quantitatively show an engaged participant pool. In fact, if pedometer retention is anything to go by, participants in this study were more engaged than any other I've conducted! Only two students lost their pedometers, and the rest of the students wore their pedometers for an average of 20 days out of 27. For each of those days, participants had to remember to take their pedometers off each night and clip them on to their clothes the next day.

Participants' website use was also within expectations: students logged in an average of 4 times each, compared to 6 logins per student for the 'social' deployment. I believe the averages might actually have been equal if I had been able to conduct two additional in-person meetings.

#### **8.4.3 In-person meetings**

Students in the 'self-tracking' study attended fewer study meetings than I had intended (and fewer than those in the 'social' study), which might have led to reduced engagement or efficacy of the system. I certainly found that for the 'social' configuration, regular in-person meetings were key to the system's success. However, if the 'self-tracking' meetings

I did attend are anything to go by, the difference may not have been nearly as stark as one might imagine. I suspect that even if the students had met an additional two times to use StepStream, the effect on their attitudes and behavior would not have been equal to that of students in the AHPC or the ‘social’ configuration. When I observed the students using StepStream, their interaction with it was very short. They logged in, looked at their historical activity and averages, and logged out. A few students congregated at one computer to compare step counts, but they quickly tired of this activity. A few minutes after they had logged in, students had returned to a central table to socialize about non-fitness topics. The ‘self-tracking’ version of StepStream just didn’t have the same *pull* I observed in the ‘social’ study. In the ‘social’ study, the permission to interact in a blended online/offline space held the students in thrall. They didn’t seem to tire of it, even after a whole hour: students’ activity on the social site continued throughout each meeting, peaking about 40 minutes into a session. I don’t think it would be possible for students using the ‘self-tracking’ system to use the StepStream website. for 10 minutes, let alone 40.

#### **8.4.4 Persuasive design elements**

Of all the potential contributors to the attitude and behavior outcomes of the ‘self-tracking’ study, the lack of social awareness *and* competitive elements in the system design is the most likely. All the elements present in the ‘self-tracking’ system (Fitbit pedometers, website platform, individual progress reports) are also part of the ‘social’ system, and are common to other pedometer systems like the AHPC. However, I designed the ‘self-tracking’ system without most persuasive features known to work well (or were predicted by social behavior change theory). The system does provide users with visibility into their own individual progress over time, and shows them a calculated ‘average’ based on their baseline week performance, but eliminates most other ‘persuasive’ design elements. The system offers no easy mechanism for data-driven social comparison, no goal-setting interface, no mechanism for peer encouragement or social support. It does not suggest ways to increase

physical activity nor does it offer a mechanism by which students might schedule exercise together.

#### **8.4.5 Summary**

I cannot say definitively how much each of the preceding factors affected the outcome of the study. The very things that make the deployment compelling—the ‘in the wild’ nature of the deployment, the small scale focus on one deployment site—also inhibit clean analysis. Certainly the small number of participants compared to the ‘social’ deployment reduces the statistical power of the survey and step count findings and prevents direct comparison, and no two schools are exactly alike. But the evidence I *have* collected strongly suggests that the deployment of a pervasive fitness system is not enough in itself to generate improved fitness attitudes or behaviors. Many things were equal, or as close to equal as possible: the school district, the socioeconomic environment, the timing of the study (both the ‘self-tracking’ and ‘social’ studies were deployed simultaneously), students’ initial attitudes, students’ willingness to engage with the deployment, and the pedometers and website infrastructure were all broadly similar across both deployments. Those factors that were not equal ought to have worked to increase attitudes and behaviors, such as students’ social cohesion and achievement orientation.

This study shows the importance of two key factors in social tools for everyday adolescent health: the scale & social connectedness of the participant population, and the presence of persuasive elements in the design of such systems.

### ***8.5 Discussion: design for existing groups***

There is no prior work in the HCI literature about deploying adolescent fitness systems to existing non-fitness-related clubs or groups. Relevant systems either deploy to a small group of 3 or 4 close friends (ChickClique [84]), an existing gym class (iFitQuest [50]), or larger groups formed specifically for the research study (the AHPC [28] and other deployments of StepStream [57]). Most health promotion studies recruit groups of students from

across a school or within an existing gym class [13]. Several health promotion studies have worked with girl scout troops (a good analogue for the leadership club my participants belong to), but these studies predominantly report teacher-led paper-based deployments [13]. One well-regarded study that did involve smart pedometers only tracked physical activity during troop meetings [71].

And yet pre-existing groups are an intriguing prospect for adolescent pervasive social fitness deployments. Such groups may already have strong social bonds and high general levels of social support. Leadership clubs and community youth groups also offer longitudinal stability. Multi-site scaling is also potentially much easier with existing groups: adults in charge could deploy and manage the technology and keep students motivated, so long as the work involved was made clear [58].

However, design guidelines for *peer support* in such groups are less clear. I'm not convinced that the unstructured social chat I designed for the 'social' version of StepStream would have had as much effect for these participants as it did for the students in my other deployments. One of the reasons StepStream was successful in the 'social' configuration was that the technology helped generate a sense of togetherness in an otherwise loosely-connected group, if only fleetingly. That allowed social support structures that were previously perhaps not as strong to begin to be formed with fitness as the background or underlying reason. This group already had strong social bonds with each other; a system designed for *them* ought to focus on leveraging this existing support rather than generating support where little had been.

Additionally, a characteristic that may be common to leadership and other pre-existing community groups of adolescents is an achievement-oriented mindset. Leadership clubs and scout troops focus on developing individual responsibility and group civic participation, and students within those settings may be especially likely to respond positively to competitive or 'badge' based mechanisms. For example, I imagine that a minimally-modified version of the AHPC would work quite well for these groups.



But the question is still open: what would a system that primarily leveraged *peer social support* and *observational learning effects* look like if I had designed it for the participants in this study? I think the answer has to do with more proscriptively structuring peer engagements, and designing activities that require mutual trust. Turn-based games or collective offline challenges (such as scavenger hunts) might be a hard sell for a loose collection of students, but might work well for existing close-knit groups.

So while the students in this study didn't appear to improve their fitness attitudes or behaviors, this deployment serves as quite a useful case study—both as a comparison to my other deployments, and as a generative exercise for thinking more deeply about the *nature* of social connections in peer-based pervasive health deployments for adolescents.

## CHAPTER IX

### DISCUSSION

In this section, I examine the role of existing social ties in social tools for everyday adolescent health, and consider the rhetoric of ‘behavior change’ with respect to my work. I also discuss future opportunities for continued research in this area.

#### *9.1 The strength of ‘weak’ forces*

The pull of competition is very strong, especially for youth-focused designs, and especially for fitness. Almost all youth-focused pedometer programs either share no data at all (using a ‘self-tracking’ approach) or are explicitly competitive (such as the AHPC) [37, 71].

In this dissertation, one of my goals was to remove competition as a core design feature, to actively work against it. And in doing so, I sought to see what else was going on, to allow a set of ‘weaker’ forces to flourish. StepStream assigns points, but they are individually specified and no running tally is visible to others. I chose not to implement leaderboards or badges, and even implemented a version of StepStream without social features.

Part of this is intuitive: I have never much enjoyed participating in or watching team sports. Every researcher should own their biases, and I recognize this bias as one of mine. But I’m in good company: social behavior change theories suggest there are many persuasive forces beyond competition (which one can think of as a strict proceduralization of social comparison). People can be motivated by the support of others, and in turn by passing that support on to others. People can be motivated by a collective sense of achievement. Even ‘social comparison’ is more than just raw peer pressure: people can be motivated by the achievement of others if that achievement appears attainable. These practices and social structures remain long after any victory.

Once ‘competition’ is removed from the equation as much as possible, untangling contributing factors is challenging. In an ecologically valid study, isolating the cause of a given behavior change is difficult to accomplish cleanly. Comparing my studies to competitive ones like the AHPC is also challenging. I used many of the same survey questions, study design, and population demographic characteristics as the AHPC, but my studies hardly count as replication. Differences such as initial attitude baselines (AHPC students maxed out many measures) and survey distribution characteristics (we were only able to deploy attitude surveys once per ‘heat’ instead of pre/post)

But at a high level, I think I can make some claims. The ‘social’ deployment led to real improvements in how participants viewed physical activity, appeared to increase the social support they gave *and* received from each other, and (for the least active) led them to increase their daily physical activity. StepStream accomplished this result without a competitive framing, and with almost no proscriptive direction at all. The findings from the ‘prototype’ and ‘self-tracking’ deployments provide evidence that attitude and behavior improvements did not come from novelty or researcher effects.

Noncompetitive forces have power, and this dissertation shows that social fitness systems can harness that power. Such systems can make encouragement and support seem normal, and they can create opportunities for exertion itself and discussing everyday fitness.

Noncompetitive forces also have limits. There’s some evidence from my interviews with high achievers that they missed a competitive aspect. The step count data back this up, to some extent, as the upper 50% did not increase their activity compared to baseline. For my ‘self-tracking’ participants, strong social support in other arenas was not enough to translate to increased social support for fitness.

Noncompetitive systems could also backfire. Although I didn’t see evidence of this in my own studies, it is possible that those who are motivated by competition could be actively demotivated in a noncompetitive setting. And the social pressures that appear to be

so motivating for some could boil over into bullying or active peer pressure. For example, I did not moderate posts on StepStream before they went live to other students. This had the benefit of giving the system a vitality and authenticity that could not be otherwise achieved, but if a student had wanted to act out within the system they could have done so to the detriment of others. Even if a designer tries to create a positive environment for social sharing, participants may turn the openness of a system like StepStream against each other.

Whether forces like observational learning effects or collective efficacy are ‘stronger’ than competition has never been the point. Surprisingly (to me, at least) this comparison became the major topic during peer review of the ‘social’ study [57]. The ‘social’ study demonstrated effects “comparable” to those one might expect in a competitive system; if the same findings had resulted from a competitive study, I would still have reported it as a success. That’s all the comparison one can justifiably make. There are simply too many factors in play to make any conclusions about relative strength of competition vs. noncompetition—barring a large-scale trial. But this work does show, at least, that there are a whole host of other noncompetitive mediating factors available for researchers and designers of behavior change interventions, and that pervasive and social computing systems can apply these to the benefit of participating youth.

## ***9.2 Beyond behavior change***

One central assumption of this dissertation is that behavior change by itself is not enough—that health behavior change systems must also affect people’s attitudes, and ultimately their self-concept, if such systems are to succeed. The psychosocial behavior change theories that underlie my work—such as Social Cognitive Theory and the Transtheoretical model—take this as given. However, the health behavior change theories I draw on are still rooted in the concept of a health professional proscribing activity to a patient, who is judged on his or her ‘compliance’ with recommendations. This goes back to their origins: the

Transtheoretical model was designed to stop people smoking cigarettes, and the health belief model was designed to get people to take a TB test. Even Social Cognitive Theory, the least proscriptive of the theories I use in this dissertation, began as a model of goal achievement.

The allure of a proscriptive, positivist framing of ‘health behavior change’ systems is easy to understand, especially for a fitness system. As I said in the ‘Related work’ section, step counts are *tractable*: they correlate with overall physical activity, they are relatively accurate for a variety of people, and they are amenable to computational analysis. Step counts represent a sort of ‘ground truth’: more steps are usually better, so it’s easy to treat pedometer readings as objective measures along a one-dimensional scale.

While no serious theory of health behavior change treats step counts as the sole measure of ‘success’ in a fitness deployment, there is still a temptation to treat other factors—such as social support, body image, and exertion enjoyment—as merely precursors to increasing steps, rather than equally important values in themselves. And for a health professional, this might be the appropriate approach. Doctors, coaches, dietitians, and public health officials want people to be well, and they want to help people prevent illness or debilitating conditions. That’s certainly a part of this work; I want to develop and study technologies that will help adolescents become and stay more physically active, and to give them new ways to understand the factors that affect their own fitness behaviors.

But as a Human-Centered Computing researcher, I’m primarily interested in the role of social health systems in people’s everyday lives. I want to understand how social and pervasive computing technologies affect, extend and mediate people’s identities and interpersonal interactions. That’s why I’ve tried to focus on building and studying technologies that help young people explore, promote, play, sustain and share their everyday health practices with each other. In my formative studies, I showed how students’ priorities and values translate into technological design considerations. I designed StepStream to embody these priorities and allow users to appropriate the technology with their own social structures and

practices. And in my two full deployments of StepStream, I described the ways in which the technological system and after-school program interacted, and explored the contributing factors to students' experiences of the deployment.

The tensions I've encountered—between *changing* behavior and understanding the *role of technology* in everyday health practices, and between designing for *individuals* and designing for *communities*—are not unique to this dissertation. Grinter, Grimes and Siek advocate 'Wellness Informatics' as a more encompassing and generative lens than 'Health' or 'Healthcare' [36]. They define Wellness Informatics as a “human-centered computing science focused on the design, deployment, and evaluation of human-facing technological solutions to promote and manage wellness acts such as the prevention of disease and the management of health” [36]. Grinter et al. identify four characteristic themes of Wellness Informatics research: numerous data sources, the 'patient' as primary user of the technology, the importance of groups and communities, and the potential for nonclinical applications beyond the healthcare establishment. My dissertation research, and StepStream in particular, matches the Wellness Informatics framing perfectly. I used multiple data sources (steps, discussion, gameplay), focused intensely on the adolescent as primary user of the technology, designed with group and school dynamics in mind, and worked outside the healthcare system.

But it would be a mistake to label this dissertation a 'Wellness Informatics' thesis. Instead, I prefer to think of Wellness Informatics—and the attendant tensions it identifies—as a rallying cry for a reinvention of health informatics from within. Human-centered computing studies can help expose assumptions embedded in theories of health behavior change, and test those theories in new ways. HCC studies can also show the value of behavior change technology as an object of study itself, and how studying technology this way feeds back into our understanding of behavior and health.

It may also be productive to look for less 'change-focused' theories or frameworks. For example, the 'Risk Perception Attitudes' (RPA) framework, developed to produce

and evaluate health awareness messaging, offers a more open structure [69]. Although an individual-focused theory, RPA has the advantage of being less concerned with ‘improvement’ on a single axis. Rather, in RPA, people move between quadrants based on their perceived risk for being harmed by their behavior and their perceived self-efficacy for taking ownership of that behavior. Thus instead of a one-dimensional journey from realization to cessation, a theory like RPA could be used to explain different people’s informational and attitudinal needs. I don’t know if RPA is the right framework for a system like StepStream, but it points the way to a more positive multidimensional approach.

The framing of ‘health behavior change’ has many advantages. It motivates my research and provides a rich array of theory, guiding both what behaviors to track *and* how to influence them. But ideally we can retain these benefits while also expanding *beyond* behavior change—to study how to help people help each other, to give people tools to do so, and to better understand how to promote and sustain healthy everyday practices, within and between exposures to ‘clinical’ settings.

### **9.3 *Future work***

There are many interesting potential future directions for my work, from different experimental designs to design implications for the website (mobile interfaces, scaffolding health and fitness discussion), to future directions in the deployment and sensor hardware design (sustainable longitudinal design, improved sensors), to different user populations (introducing competition and designing for existing groups).

#### **9.3.1 *Alternate experimental designs***

Studying social and local behavior presents challenges for experimental design. Designing a control and experimental condition is particularly challenging—in a traditional study, I would be able to test certain features on one group and not on another, with those two groups being identical in all other respects. But social features complicate this picture, especially ones tied to a local environment like those I was testing with StepStream. It would

have been impractical, for example, to randomly split students in the same school in to "social" and "non-social" groups. In the end, the approach I tried—finding similar schools and deploying a different version at each—was still unsatisfying. Even extremely similar schools can have distinct social atmospheres, as was certainly the case in the StepStream studies.

In the end, I decided to control for as many variables as I could and treat the two deployments (at the 'social' and 'individual' schools) as cases for comparison. This allowed for rich, ecologically valid studies, but limited my ability to pinpoint individual design features. In designing a follow-up study or larger-scale trial, I would do things differently. First, I would add a low/no-tech condition, where participants wear pedometers but do not interact with a website or have a chance to review their individual progress. That way I could have a clearer idea of the effect (on behavior & attitudes) of simply instrumenting participants. I would also like to try varying conditions in a within-subjects design, where participants would be involved in several 'phases' of the system. One phase would be the 'social' version, another the 'individual' version. I'd work with multiple groups in the same school, and each group would receive all conditions, counterbalanced for order effects. It's possible that to get statistically significant findings from a study like this I might have to recruit many more students from one school. This would increase the difficulty of recruitment (and possibly increase withdrawal or abandonment rates) but if those challenges could be overcome the results would be much clearer.

I would also like to study a system like StepStream over a longer period regardless. Four weeks is long for an HCI study, but relatively short for a study that aims for long-term effects. However, in planning my StepStream deployments, I encountered an interesting challenge: it's actually quite hard to find even a four-week window for a school-based study without encountering aberrations, such as standardized testing, long weekends or week-long breaks. Deployments that are slightly longer (perhaps 5 or 6 weeks) would inevitably run into such breaks. Longer deployments also increase the risk of demotivating



participants, or causing lack of interest. An ideal solution would be one that allowed people to ‘fall away’ and come back. In future versions of StepStream, an interesting approach would be to adapt the AHPC’s strategy of ‘heats’, once-a-semester bursts of activity with fallow time in between. As researchers, we could study the ‘stickiness’ of attitude and behavior changes, and as deliverers of after school programs, we could maintain interaction with the school without overstaying our welcome. Sustainable longitudinal interaction is a big challenge for systems like StepStream, and a much needed area of study.

### **9.3.2 Mobile interaction**

When I developed StepStream, students in my target population were not predominantly smartphone users. This meant that StepStream was a desktop website with an in-school base station. However, future systems built on the ideas in this work will likely be mobile-first, if not mobile-only. Android and iOS devices are now predominant and powerful enough to act as both display interfaces and sensor hubs. Students could more easily use StepStream between meetings, and the phones themselves could act as personal base stations for sensing, reducing reliance on school infrastructure. There would also be fewer technical hurdles to between-meeting interaction, and students would not have to ask their parents’ permission to use a home computer to access the system. However, a mobile-first solution might tempt one to reduce or eliminate the weekly after-school meetings (whose purpose, nominally, was to log into the system from school computers). Figuring out new ways of constructing those ritual online/offline collective experiences would be an interesting challenge with no clear solutions. Similarly, figuring out how to encourage more asynchronous system use via the phone would also be a significant achievement.

### **9.3.3 Facilitating discussion**

StepStream made little attempt to structure students’ discussion, apart from a rotating set of health-related prompts. However, as students used a system like StepStream over time,

it would be useful to be able to guide their interaction a little more, to give them scaffolding for more direct health-related social support. This is a tricky task, because an overly constrained or proscriptive approach might ruin the fun and authenticity of StepStream's social chat. Perhaps a series of 'journaling' style micro-surveys that appeared immediately after login might encourage such discussion. Similarly, it would be interesting to find ways for students to build up a 'knowledge base' of tips and success strategies.

#### **9.3.4 Coopetition?**

I spent much of this dissertation distancing my approach from traditionally competitive ones. However, it is still true that some students are motivated by competition, and that for those students it works better than any other mechanism. Perhaps there is a way to add a variety of play styles into future versions of StepStream. The key here would be to add competition without ruining the cooperative mutual awareness enabled by StepStream. Is there a way to merge competitive and collaborative design characteristics in the same system, or would they overwhelm each other? Beyond the competition/cooperation dichotomy, it would also be interesting to see if we could design for the multiple emergent play styles found in the AHPC [88] within one system, or whether it might be a better approach to target subgroups (e.g. by gender) instead of designing for every student in a certain school.

#### **9.3.5 Design for existing groups**

One particularly interesting subgroup (not quite covered by the 'player types') is designing for existing structured groups or clubs. As discussed in Chapter 8, there are several advantages to designing with existing group dynamics in mind. Where StepStream worked in a setting with relatively weak ties, designing for a group with strong ties already would have many implications for design. Rather than encouraging students to form social bonds around fitness and the after-school program itself, a design for existing groups could leverage those existing structures and encourage students to translate existing social support to

fitness or health-related topics. This has not previously been done within HCI (at least for fitness systems) and would be an interesting future approach.

### **9.3.6 Changing sensors**

This dissertation focused on dedicated pedometers sensing approximate step counts using accelerometers, but there are many other potential behaviors to track and ways to sense them. In terms of physical fitness, the national recommendations are not in ‘step counts’ but instead focus on minutes of elevated heart rate. Perhaps a future version of StepStream could incorporate heart rate sensing (maybe pre/post exercise, or continuous during an exertion activity). There are also many interesting possibilities if the design of the pedometer itself is part of future work. Perhaps the pedometers could give off social signals, or buzz when a user hit their daily average. Maybe users could customize their pedometer’s shell to make it a vehicle for individual expression (and perhaps cut down on pedometer loss).

## CHAPTER X

### CONCLUSION

In this dissertation, I have tested the following thesis: *A school-based social fitness approach to everyday adolescent health can positively influence offline health behaviors in real-world settings. Furthermore, a noncompetitive social fitness system can perform comparably in attitude and behavior change to more competitive or direct-comparison systems, especially for those most in need of behavior change.*

After conducting formative design exercises and building a system of my own, I conducted three month-long deployments of StepStream, each configured differently to allow me to study different aspects of the system. I also compare my work on StepStream to my prior research studying the American Horsepower Challenge.

#### ***10.1 Contributions***

In this dissertation, I have made the following contributions:

**The identification of tensions and priorities for the design of everyday health systems for adolescents.** In my formative design studies (Chapter 4), I identified four key design tensions for everyday health games for adolescents: social presence, gender effects, incentives and competition. In my ‘self-tracking’ StepStream study (Chapter 7), I showed how the social structure of the participant group affected the deployment.

**A design overview of StepStream, a social tool for everyday adolescent health** I report the design and development of StepStream (Chapter 5). The system has two versions, a ‘self-tracking’ version and one with additional ‘social’ features. I also included a game based on the formative design projects, and tried to eliminate many known persuasive features, such as leaderboards and badges.

**A description of StepStream’s deployment from a socio-technical perspective, describing the intervention as a school-based pervasive computing system** I described the design of the website as well as the socio-technical system, including the base station, pedometers and after school program (Chapter 6). I also showed how social factors, in-person meetings, and other environmental features of StepStream affect the deployment in Chapters 7 and 8.

**An empirical study of a noncompetitive awareness system for physical activity** I report findings from a deployment of the ‘social’ version of StepStream, and show how the system affected students’ attitudes and physical activity.

**A comparison of this system in two configurations in two different middle schools** I also deployed a ‘self-tracking’ variant of StepStream in a second school, and used this deployment to

**An analysis of observational learning and collective efficacy in a pervasive health system** I showed how a pervasive social health system that encourages students’ social interactions with respect to physical activity and creates opportunities for collective experiences can lead to positive health outcomes (Chapter 7).

## ***10.2 Summary***

I found that a noncompetitive system *can* encourage adolescents to increase their daily activity, support each other in maintaining that activity, and and make fitness more enjoyable. Through my ‘prototype’ and ‘self-tracking’ studies, I showed that these effects are not due merely to novelty or researcher effects, and showed the impact of other factors, such as existing social structures within the participant group and students’ achievement orientation.

## **APPENDIX A**

### **SURVEYS AND MEASURES**

#### ***A.1 Formative design prompt***

For the formative design exercises, I asked students “Design a game that you and your friends would play to get and stay healthy.” Students worked in groups of 3-5 to generate design concepts, and I gave them feedback throughout. Groups began with the worksheet that structured their initial design work into 6 sections. I also created a worksheet for teachers and other researchers to ask student groups during the exercise.

<b>Quick Pitch</b> (convince others to play!)	<b>Gameplay</b> (how will your game work?)	<b>Activities</b> (what you track, like “steps”)
<b>Sensing</b> (how you'll track the activity)	<b>Sharing</b> (how to make it social)	<b>Rewards</b> (how to encourage play)

## Design Exercise: Teacher Worksheet

Here are some questions to ask groups if they get stuck.

- *Gameplay: how will people play your game?*
  - This is the most important part! There are many ways to make a game fun. If you're having trouble, think about how some of your favorite games work. Maybe you want to turn your neighborhood into a giant game of Monopoly? Some more things to consider:
  - Will people play at the same time? Just because a game is social doesn't mean you all have to meet up to play. Maybe you each take turns. Maybe the game extends over a month.
  - How long will it take to play the game? Can your game be played in a few minutes per day, or will it take longer? Is your game a one-off experience or a continuous competition?
- *Activities: what to track?*
  - What healthy activities do you want to encourage?
  - Choose activities that you and your friends either do frequently already, or wouldn't mind doing on a regular basis. This might be something as simple as walking or eating lunch, or maybe your game involves an unusual activity, like jumping jacks or pushups.
- *Sensing: how to track it?*
  - What activities can you measure, and how will you measure them?
  - You've seen a bunch of sensing devices today. Can your activity be tracked by any of them? It's okay if your sensing device doesn't exist yet. But be sure to think about how someone would feel using your sensor. Would it be too bulky or uncomfortable? Would it invade their privacy?
  - You don't have to use sensors, if you think you can trust your friends to report their own activity. But remember, people don't like entering in data!
- *Sharing: how to make it social?*
  - How will you share the activities your game tracks?
  - The heart of your game should be the way it lets you and your friends share your activities and talk about them.
- *Rewards: how to encourage your activity?*
  - Why would someone want to play your game?
  - There are many kinds of rewards. Maybe players get points each time they perform an activity. Maybe players earn badges or trophies for doing especially well. Maybe players can give points to each other for encouragement. Which rewards match best with your game?



## ***A.2 Deployment survey***

For pre/post comparison, I asked students a series of questions about themselves, their physical activity, and their social support for physical activity. The pre/post surveys were identical, except for the addition of a "StepStream" page, so I have only included the post-study survey here.

The first page asks for the student's name and pedometer number. In my own spreadsheets, I used the pedometer number rather than the participant name as the primary key. On the second page, I asked for basic demographic information (age, gender, ethnicity, height and weight). I used the age, gender, height and weight to generate a rough BMI for the student. I also asked students some basic digital literacy questions (5: 'you online').

The second page ('About Me') contains questions designed to elicit a general sense of students' perspectives on their own body and health. This and all following sections contain a subset of the questions asked of students participating in the AHPC. The third page contains questions that ask students about their own physical activity in absolute terms and related to peers. Page 5 ('My Friends') contains a number of questions about the social support students give and receive for health and fitness.

Finally, the last page asks some basic usability and enjoyment questions about StepStream itself. This page served as a prompt for a quick post-survey focus group with all students, before I conducted smaller focus groups using the focus group instrument.

## 1. Introduction

Page 1 of 6

Hello!

We are scientists at the Georgia Institute of Technology in Atlanta, Georgia. We hope you can help us with our study. We want to learn more about how kids and teenagers think about things like video games, exercise, and sports. From what we learn, we plan to design games that kids and teenagers like yourself enjoy playing.

On the following pages, we want to know what you think about video games, sports, and exercise. We're also interested in learning about the kinds of things that you do at school and at home. We want to hear everything you have to say. It should take you about 15 minutes to answer all the questions.

**There are no right or wrong answers to these questions. Please answer as honestly as you can. We won't show your answers to your teachers, parents, or friends.**

Thank you for your help with this important study!

Your Name

Pedometer

*Post-Intervention Student Survey*

## 2. About Me

Page 2 of 6

These questions ask about what you are like.

Remember, your teachers, parents and friends won't see the answers you choose.

### 1. Age

 years

### 2. Gender

- ☐ Male  
☐ Female

### 3. Ethnicity

I consider myself to be (check all that apply)

- |  |   |
|--|---|
| <input type="checkbox"/> Caucasian (White)         | <input type="checkbox"/> African-American or Black          |
| <input type="checkbox"/> Hispanic or Latino/Latina | <input type="checkbox"/> Native Hawaiian / Pacific Islander |
| <input type="checkbox"/> Asian                     | <input type="checkbox"/> American Indian / Native Alaskan   |
| <input type="checkbox"/> Other                     | <input type="checkbox"/> Prefer not to answer               |

### 4. Height & Weight

My height is:

 feet and inches

My weight is:

 pounds

### 5. You Online

Do you have access to the Internet on a **home** computer?

- ☐ Yes ☐ No

During an average day, how many hours do you use a computer?

 hours

Do you think of your **online** self as different from your **offline** self?

- ☐ Yes ☐ No

Do you like to create new perceptions of yourself online when no one can see the real you?

- ☐ Yes ☐ No

Do you feel that your online presence reflects the real you or are you playing a role?

- ☐ Reflects the real me ☐ I'm playing a role

*Post-Intervention Student Survey*

## 2. About Me (continued)

Page 3 of 6

These questions ask about what you are like. Check the sentence in each pair that is more like YOU. Please answer as honestly as you can. Remember, your teachers, parents and friends won't see the answers you choose.

**1. Check the sentence in each pair that is more like YOU.**

- ☐ I do very well at all kinds of sports
- ☐ I **DON'T** feel I am very good when it comes to sports.

**2. Check the sentence in each pair that is more like YOU.**

- ☐ I wish I could be a lot better at sports.
- ☐ I feel I am good enough at sports.

**3. Check the sentence in each pair that is more like YOU.**

- ☐ I think I could do well at sports I have not tried before.
- ☐ I am afraid I might **NOT** do well at sports I have not tried.

**4. Check the sentence in each pair that is more like YOU.**

- ☐ I usually watch games and sports.
- ☐ I usually play games and sports.

**5. Check the sentence in each pair that is more like YOU.**

- ☐ I am happy with my height.
- ☐ I wish my height were different.

**6. Check the sentence in each pair that is more like YOU.**

- ☐ I am happy with my weight.
- ☐ I wish my weight were different.

**7. Check the sentence in each pair that is more like YOU.**

- ☐ I am **NOT** overweight.
- ☐ I wish I were thinner.

**8. Check the sentence in each pair that is more like YOU.**

- ☐ I am often unhappy with myself.
- ☐ I am pretty pleased with myself.

**9. Check the sentence in each pair that is more like YOU.**

- ☐ I like the kind of person I am.
- ☐ I wish I were someone else.

**10. Check the sentence in each pair that is more like YOU.**

- ☐ I am happy being the way I am.
- ☐ I wish I were different.

*Post-Intervention Student Survey*

### 3. Physical activity that I do

Page 4 of 6

**1. During a typical week, how many times do you usually do the following types of exercise for at least 15 minutes?**

number of times per week

In an average week, I do STRENUOUS EXERCISE  
(makes my heart beat rapidly) for at least fifteen minutes:

In an average week, I do MODERATE EXERCISE  
(makes me sweat after 10-15 minutes) for at least fifteen minutes:

In an average week, I do MILD EXERCISE  
(doesn't make me sweat much) for at least fifteen minutes:

**2. In your own opinion, which best describes your physical activity level on most days?**

- ☐ Very Low
- ☐ Low
- ☐ Medium
- ☐ High
- ☐ Very High

**3. Compared to other people your age, how does your activity level compare?**

- ☐ I am more active than most people my age.
- ☐ I am active about the same amount as most people my age.
- ☐ I am less active than most people my age.

**4. How does physical activity make you feel?**

I disagree a lot

I agree a lot

It gives me energy

☐ ☐ ☐ ☐ ☐

I enjoy it

☐ ☐ ☐ ☐ ☐

*Post-Intervention Student Survey*

## 4. My friends

Page 5 of 6

1. Below is a list of things people might do or say to someone who is trying to exercise regularly. Please answer as honestly as you can. Remember, your teachers, parents, and friends won't see the answers you choose.

**In this question, think about how often in the past month your FRIENDS have said or done what is described below.**

	Not at all	Rarely	A few times	Often	Very often
Exercised with me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Offered to exercise with me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gave me helpful reminders to exercise ("Are you going to exercise tonight?")	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gave me encouragement to stick with my exercise program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Changed their schedule so we could exercise together	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussed exercise with me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Complained about the amount of time I spend exercising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Criticized me or made fun of me for exercising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gave me rewards for exercising (bought me something or gave me something I like)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Planned for exercise on recreational outings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Helped plan activities around my exercise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Asked me for ideas on how <b>THEY</b> can get more exercise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Talked about how much they like to exercise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*Post-Intervention Student Survey*

## 5. StepStream

Page 6 of 6

**1. From the list of words and phrases below, circle 3 that describe StepStream**

energizing	embarrassing	tiring
fun	frustrating	disappointing
a pain	building team spirit	inspiring
challenging	cool	boring
healthy	silly	hard work
different	building leadership	good for me
time-consuming	dumb	cute
confusing	a blast	awesome
memorable	exciting	kiddish
weird	uncomfortable	motivating

**2. What's something you personally did to get more steps?**

**3. If kids at another school had a chance to play StepStream, what would you tell them?**

**4. What would you change about StepStream to make it better?**

*Post-Intervention Student Survey*

### ***A.3 Focus group instrument***

I conducted several focus groups after each deployment of StepStream, and I used the following prompt as a guide for the focus groups. This focus group prompt is adapted from the prompt I used during the AHPC on-site interviews. It contains an elicitation exercise (Stepstream & You), and several guided discussion topics (Healthy Behaviors, Activity Preferences, Perceptions). Finally, in order to get participants' personal views, I asked them to tell a fictional 'other student' about the program, highlighting both positive and negative aspects of their experience.



## Focus Group: StepStream Reflections

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This set of prompts will guide our discussion about students' experiences with the prototype system. As students bring up different points, we may ask follow-up questions and to elicit responses from other students.

### **Opening Activity**

To start, I'm going to give each one of you a piece of paper. Do you all have something to write with?

On this page you'll see a list of words and phrases at the top and then a blank area at the bottom. I want you to do 2 things.

1. At the top, circle 3 words or phrases that you think best describe StepStream
2. At the bottom, write down some of the things you, personally, did to get steps.

*See next page for opening activity sample*

## StepStream & You

Your Name: \_\_\_\_\_

From the list of words and phrases below, circle 3 that describe StepStream:

energizing	embarrassing	tiring
fun	frustrating	disappointing
a pain	building team spirit	inspiring
challenging	cool	boring
healthy	silly	hard work
different	building leadership	good for me
time-consuming	dumb	cute
confusing	a blast	awesome
memorable	exciting	kiddish
weird	uncomfortable	motivating

**Part 2:** Write down examples of things you, personally, did to earn steps/points

### 1. Healthy Behaviors

Now, I want you to think about using StepStream. Think about the past week. What kind of things did you do to earn points?

- 1.1 Can anyone tell me something you did to get steps that is cool, funny, or creative?
- 1.2 What things did you do at school? at home? other places?
- 1.3 Did you do these things before trying StepStream?
- 1.4 What **NEW** things did you try during your time using StepStream?
- 1.5 What activities got you the **MOST** steps?

### 2. Activity Preferences: Group vs. Individual

From what you told me, I heard some things that you did together and some things you could do on your own.

- 2.1 Let me see a show of hands. Who really liked doing things with at least one other person to get points?
  - 2.1.1 **What** did you do? **Who** did that with you?
  - 2.1.2 What made that work for you?
  - 2.1.3 Do you think you would have gotten as many points if you'd tried to do that same thing on your own?
  - 2.1.4 Did you use StepStream to arrange the activity, or some other way?
- 2.2 Who really liked doing things you could do **on your own** to get points?
  - 2.2.1 What made that work for you?
  - 2.2.2 Do you think you would have gotten as many points if you'd tried to do everything with someone else?
- 2.3 Let's talk about the "Tips" feature. With a show of hands, how many of you used the tips feature?
  - 2.3.1 Can someone tell me about a tip that you made? Did anyone use it?
  - 2.3.2 Can someone tell me about a tip from someone else that they used? What about that tip made you want to use it?
  - 2.3.3 Who here never used the tips feature? How could we change it to make it more interesting for you?

### 3. Perceptions of the System

3.2 Now I want you to look at the **top of your paper**. Who wants to volunteer to tell me what you circled there?

- 3.2.1 What made it seem \_\_\_\_\_ to you?
- 3.2.2 What part of it was most \_\_\_\_\_?
- 3.2.3 If you were making up the game for your class, what would you have done differently to make it more/less \_\_\_\_?

#### 4. Long-term Attitudes/Behavior Change

4.2 If kids **at another school** had a chance to do this and asked you what you thought of it, **what would you tell them**?

4.2.1 What **advice** would you give them?

4.2.2 What would you tell them is **fun** about the system?

4.2.3 What would you tell them is **not fun** about the system?

#### ***A.4 Pedomter & survey data***

The following tables summarize the data from pedometer logs and surveys. Each column in the survey data refers to a question from the surveys included earlier in this appendix. Likert ratings are described using their scale degree (1 being the lowest). On yes/no questions I code 1 for no, 2 for yes.

Step data for "self-tracking" school

Day	Ped 1	Ped 2	Ped 3	Ped 4	Ped 5	Ped 6	Ped 7	Ped 8	Ped 9	Ped 10	Ped 11
1	5329	4932	1463	5904		1002	796		2940		4263
2	4751	611	7060	4176			3382		4927		16022
3	5329	365	3712	2733			2538		2496		
4	5086	2535	6454	6225		4269	1106		6948		
5	3482		6962	6720		5087	3580	9696	6114		7023
6	3257		5321	4484		4576	4245	7038	4474	3319	7016
7	3126		686	6454		3764	4876	13787		5086	7016
8	2747			7777		3116	5234	9954		8515	
9	3037			10537				8287		2400	
10	1756			5928			315			1382	
11	3600			6017		4062	4971	3396		3825	
12	2782			8212		3631	8168	4450		4717	
13	4350			5873		5459	7037	5979	3943	5533	2464
14	4609			8215		5185	4605	8325	5966	7295	
15	6245			7244		463	5447		9294	9750	
16	3773			8630		1312	6258	1990	16148	82	
17	1061			5892			1530	3552	8079		
18	3248			6437		3509	7052	5452	6395		2302
19	4132			6439		5563	6562	7155	6556	6246	5006
20	3964	1061	1061	5566	1007	1875	4448	7717	5296	4778	4322
21	8390	668	6085	5122	650	6728	3917		8834	8341	7273
22	7470		5212	9128		5991	4762	10395	11833	4162	2732
23	3521		1239	7267				4076	11195		
24			2912	8124			1729		4378		
25	4086			5564		3250	7562	8425	5399	598	
26	6829		2444	8297		6540	11037		8328		
27	3580		4127	5080		4177	3943	6642	5216	6012	

Step data for "social" school (Pedometers 1-21)

Day	Ped 1	Ped 2	Ped 3	Ped 4	Ped 5	Ped 6	Ped 7	Ped 8	Ped 9	Ped 10	Ped 11	Ped 12	Ped 13	Ped 14	Ped 15	Ped 16	Ped 17	Ped 18	Ped 19	Ped 20	Ped 21
1	4482	9034	7151	5240		4322		15225	1153	10158		2318		7063	4820	8125	741	406	6540	5577	17527
2	9979	7448	1356	3117				14587	3376	3989						2940				4263	16595
3	11450	3536	8268	2338				17835	5075	7132							4927			16022	16993
4		12018	3446	1887				16762	6440	4797					3679	2496					15722
5		844	5201	3727				10051	10399	9621					4084	6848					8527
6		9014		2895				1278	6632	8906				6878	3888	6114				7023	9639
7		7322	6431	1590	609	4484			7023	9328	2326			3130	2648	4474	3676	3319		7016	11277
8		7581	2606	4512	1661	6809			6033	7892	6179				4051		8150	5086		7016	12908
9		6275		9027		4783			4408	3788	892			5560	4328		302	8515			17545
10						1165									3232		8698	2400			
11		6962		12874		1678									2568		7980	1382			16885
12		10044		4197		6958									4474		9461	3825			9206
13		5846		5179												3067	10837	4717			13810
14		8095		3962	4653	16118			4365	3993				1873	3114	3943	7192	5533		2464	7974
15		7263		4272	2081				6984	5016				3771	4774	5966	7613	7295			20148
16	14172	7555		4883	6053				7912	5117				8595	3684	9294	2981	9750			15963
17				12411	12129				1273					4830	4285	16148					14732
18				6012	2229				2576					5560	4372	8079					4465
19				4810					8039					12099	4302	6395					10583
20				3870	4557	3902								7325	4700	6556		6246			12118
21	3989		3504	4655	5093	4806			7406					6304	4027	5296		4778			10624
22			8395	6094	3636				6789	5538					4409	8834		8341			17093
23				5074	9740				12824	6402				3859	10308	11833		4162			
24			5820	9413		4012					1631				2941	11195					17807
25			2247	1659		328					1512					4378					6126
26				7027	3931	2652					6985				3920	5399		598			9752
27				6238											3463	8328					8078

Step data for "social" school (Pedometers 22-42)

Day	Ped 22	Ped 23	Ped 24	Ped 25	Ped 26	Ped 27	Ped 28	Ped 29	Ped 30	Ped 31	Ped 32	Ped 33	Ped 34	Ped 35	Ped 36	Ped 37	Ped 38	Ped 39	Ped 40	Ped 41	Ped 42
1		5594	15426	13095	6858		7751	4881	10218		8485	8318	7508			5640	6453				14938
2			6684	7000			5667				5913	3283	11062	7648							24991
3			268	19251			2034				8260	3032		5400					10034		22075
4	513		8787	6574			2960				5369			8000							1753
5	5041		5117	8229				6631	4067		4617	2827	4400	6700			6064		3378		8339
6	7036		12722	8824				3455	6094		6095		7630	7840					8377		366
7	4899		5337	2382		666		4722	8109		5503	3722	8005	3290		7101	4645	7507	5453	6812	11401
8	3768			6597		1685		4222	5609		13618			6384	1718	8835	10585	14108	7659	7168	2058
9	7558			15583				11163	9797		8200		6769	5735		1364	17808	8596	10406	1589	
10	2892		3103					1155	12475		3831	2259	4048	9787			4049		10784		
11	424								1325		5688		6001				257		11459		
12	3297			9032				3141	12791		4685		8800	4653			3965		4391		
13	11540			10804				4063	10091		6773	4679	4889	5041			9955		3182		
14	7116	6642		11406		2599	2143	3932	6387	7324	8016	4172	5073	5987	4450	3276	4459				1856
15	4665	5416		3322		6140	5529	3689	12684	8074	4538	8830	1138	12082	5571	7557	4768		4437		
16	5881			10813		5647	5814	5063	6469	4905	12477		6668	13202	4296		4672		14420		
17						3367	6373		5380		9423		5039	4130	4777		1589		5589		
18						5865	1746		556		3596		2262		2916		2529				
19	3378		6142			5798	5250	4308	15782		12926		3650	4892	6835		5361		3881		
20	4358					4777	1297	5150	6763		16361			4717			6579		7387		
21	3092		5327			7040	5099	4360	10429		7689		4748	5014	8144		5828		3561		
22			16703	6549		6472	8940	3873	5987		8025		11803	7293	5809		2384		8934		
23			10225			10804		12581	11523		3888		4280	10869	13284				9367		
24						6236	4386	2037	6088				4956	7924	7946						
25						3397		4497	1681					7115							
26			6866			2428	6190	5388	287					3530					4029		
27							5399	6720	1516					4013					5340		



Demographics for “self-tracking” school

Ped	Age	Gender	Ethnicity	Height	Weight	Internet @Home	HoursOn Computer /day	OnlineVs Offline	New Perceptions	Real/ Role
4	14	F	Black	5'1	114	Y	3	N	N	Real
9	13	F	Black	5'5	175	Y	5	Y	N	Real
16	13	F	Black	5'8	185	Y	4	N	N	Real
18	14	F	Black	5'9	132	Y	4	N	N	Real
21	13	M	Black	5'5	125	Y	3	N	N	Real
23	14	M	Black	5'5	185	Y		Y	N	Real
25	14	F	Black	5'1	107	Y	3	N	N	Real

Demographics for "social" school

Ped	Age	Gender	Ethnicity	Height	Weight	Internet @Home	HoursOn Computer/day	OnlineVs Offline	New Perceptions	Real/Role
2	13	M	Black	5'4	132	Y	1	N	N	Real
3	13	M	Hispanic	5'7	135					
6	12	M	Black	5'5	108	Y	1	N	N	Real
7	15	F	Black	5'7	179	Y	4	N	N	Real
10	13	F	Black	5'2	97	Y	5	N	N	Real
12	14	M	Black	5'5	135					
15	13	F	Black/Native	5'2	117	Y	24	N	N	Real
17	13	M	Black	5'1	103	Y	3	Y	Y	Real
19	13	F	Black	5'2	128	Y	24	N	N	Real
20	12	F	Black	5'4	99	Y	3	N	N	Real
21	13	F	Black	4'9	77	Y	24	N	Y	Real
22	13	M	Asian	5'7	130	Y	1	N	N	Real
23	11	F	Black	5'6	240	Y	4.5	N	N	Real
24	11	M	Black	4'8	102	Y	1.5	N	N	Real
25	11	F	Black	4'11	77	Y	1	Y	N	Role
26	12	M	Black/Other	5'2.5	148	Y	0.75	Y	N	Real
27	13	F	Asian	4'11	97	Y	7	N	N	Real
29	12	F	Black	4'11	92	Y	2	N	N	Real
32	13	F	Asian	4'11	130	Y	5	N	N	Real
34	12	F	Asian	5'1	99	Y	1.5	Y	Y	Role
35	12	M	Black	5'4	102.3	Y	1	Y	Y	Real
36	13	M	Black	5'	108	Y	2	N	N	Real
38	13	F	Asian	5'2	84					
40	12	F	Black	5'0	82	Y	3	N	N	Real
42	14	M	Hispanic	5'1	93	Y	1	N	N	Role
44	14	M	Black	5'2	105					
46	12	F	White/Black/Native	4'11	100	Y	1.5	N	N	Real
47	12	M	Black	5'2	105	N	-	-	-	-
48	12	F	Asian	5'5	88	Y	2	N	Y	Real
49	12	M	Black	5'2	96	Y	2	N	Y	Real

'About Me' for "self-tracking" school

Ped	Do well at sports PRE	Do well at sports POST	Wish I could be better at sports PRE	Wish I could be better at sports POST	New sports PRE	New sports POST	Watch sports PRE	Watch sports POST	Happy with height PRE	Happy with height POST	happy with weight PRE	happy with weight POST	not over weight PRE	not over weight POST	unhappy PRE	unhappy POST	like myself PRE	like myself POST	happy being me PRE	happy being me POST
1	2	2	1	2	2	2	1	1	1	1	2	2	2	2	1	1	2	2	2	2
2	1	1	2	2	1	1	2	1	1	1	1	1	1	1	2	1	2	2	2	2
3	2	2	2	2	2	2	2	2	1	2	1	1	1	1	1	1	2	2	2	2
4	1	1	2	2	2	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2
5	2	2	1	1	2	2	1	2	2	2	2	2	2	2	1	1	2	2	2	2
6	1	1	2	2	1	2	2	2	2	2	1	1	1	1	1	1	2	2	2	2
7	2	2	1	1	2	2	1	2	2	2	2	2	2	2	1	1	2	2	2	2

'About Me' for "social" school

Ped	Do well at sports PRE	Do well at sports POST	Wish I could be better at sports PRE	Wish I could be better at sports POST	New sports PRE	New sports POST	Watch sports PRE	Watch sports POST	Happy with height PRE	Happy with height POST	happy with weight PRE	happy with weight POST	not over weight PRE	not over weight POST	unhappy PRE	unhappy POST	like myself PRE	like myself POST	happy being me PRE	happy being me POST
1	2	2	2	1	2	2	2	1	1	2	2	2	2	2	1	1	2	2	2	2
2	2	2	2	1	1	1	1	1	2	2	2	2	2	2	1	1	2	2	2	2
3	1	1	2	2	2	1	2	1	2	2	2	2	1	1	1	1	2	2	2	2
4	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
5	2	2	2	1	1	1	2	1	2	2	2	2	2	2	1	1	2	2	2	2
6	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
7	1	1	2	2	1	1	2	2	2	2	2	2	2	2	1	1	1	2	2	2
8	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2
9	2	2	2	1	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2
10	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
11	2	2	2	1	1	2	2	1	2	2	2	2	1	2	1	1	2	2	2	2
12	2	2	2	2	2	2	2	1	2	2	2	2	1	2	1	1	2	2	2	2
13	2	2	2	1	1	1	2	1	2	2	2	2	1	2	1	1	2	2	2	2
14	2	2	2	2	1	2	1	1	1	1	2	2	1	2	1	1	2	2	2	2
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2
16	2	2	2	2	1	1	2	2	1	2	2	2	2	2	1	1	2	2	2	2
17	1	1	2	2	2	1	1	2	2	1	1	1	1	1	1	1	2	2	2	2
18	2	2	2	1	1	1	2	1	2	2	1	1	1	2	1	1	2	2	2	2
19	1	1	2	2	2	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
20	2	2	2	1	1	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2
21	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
22	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
23	2	2	2	1	1	2	2	1	1	2	2	2	2	2	1	1	2	2	2	2
24	2	2	2	1	1	2	2	1	2	2	2	2	2	2	1	1	2	2	2	2
25	1	1	2	2	2	2	2	1	2	2	2	2	1	2	1	1	2	2	2	2
26	2	2	2	1	1	1	1	1	2	2	2	2	2	2	1	1	2	1	2	1

'Physical Activity' for "self-tracking" school

Ped	PRE- Strenuous	Strenuous	PRE- Moderate	Moderate	PRE-Mild	Mild	PRE- Activity	Activity level	PRE- Compare	Compare	PRE- Active energy	Active energy	PRE- Active enjoy	Active enjoy
1	0	0	0	0	0	0	1	3	3	1	2	2	1	2
2	1	1	2	1	3	3	2	2	1	3	3	3	2	3
3	0	0	2	0	2	2	2	2	3	3	3	2	3	3
4	2	2	3	4	4	4	4	3	3	2	2	3	4	4
5	2	4	3	5	3	3	3	4	4	1	1	4	4	4
6	0	1	4	4	5	5	7	2	2	2	2	2	3	3
7	0	0	2	2	5	5	0	3	2	2	2	3	4	4

'Physical Activity' for "social" school

Ped	PRE- Strenuous	Strenuous	PRE- Moderate	Moderate	PRE-Mild	Mild	PRE- Activity	Activity level	PRE- Compare	Compare	PRE- Active energy	Active energy	PRE- Active enjoy	Active enjoy
1	15	20	10	13	5	8	3	3	3	2	4	4	4	4
2	2	3	7	7	2	5	4	4	3	2	2	2	2	2
3	2	2	3	3	1	4	3	3	2	1	2	2	3	3
4	3	3	2	1	10	3	4	3	2	2	2	3	2	5
5	6	5	6	2	1	10	4	4	3	3	2	2	3	4
6	2	5	5	7	4	7	4	4	2	2	3	5	4	4
7	10	0	0	0	0	0	3	2	2	2	3	4	4	5
8	0	0	1	2	3	5	2	3	2	2	2	2	4	4
9	3	3	2	4	1	6	4	3	3	3	2	3	2	2
10	3	3	2	2	2	1	3	4	2	3	2	2	2	1
11	4	10	5	10	3	10	3	3	3	3	3	4	1	3
12			1	3			3	4	2	3	2	2	3	3
13							4	5	3	3	4	2	4	4
14	1	2	4	3	6	1	3	3	1	2	4	1	2	4
15	3	3	1	4	4	3	3	3	3	3	3	3	3	2
16	3	4	2	1	6	0	3	4	2	3	4	3	5	4
17	3	3	2	3	2	2	3	3	2	2	3	3	5	5
18	0	5	15	3	15	5	3	5	2	3	4	4	2	4
19	0	2	0	1	3	2	3	3	2	2	2	3	1	4
20	3	3	5	4	4	2	5	4	3	3	3	3	5	5
21			1	4			4	4	2	2	3	3	3	3
22	5	5	2	1	1	2	4	4	2	2	1	4	4	2
23	10	10	10	10	10	10	5	5	3	3	5	5	3	3
24	5	3	4	2	1	0	5	4	3	3	5	5	4	4
25	1	2	2	4	4	1	3	3	2	2	4	2	4	4
26	5	6	2	2	3	5	4	5	3	3	5	5	2	5

'Friends' for "self-tracking" school

Ped	PRE- exer cise	PRE- exer cise	PRE- offer ed	PRE- remi nder s	PRE- enco urag eme nt	PRE- sche dule	PRE- sche dule	PRE- disc uss	PRE- disc uss	PRE- com plain	PRE- critic ized	PRE- critic ized	PRE- rewa rds	PRE- plan ned	PRE- plan ned	PRE- help ed	PRE- help ed	PRE- ask plan	PRE- ask plan	PRE- talk	PRE- talk
1	2	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	2	3	1	2	2	1	1	1	1	1	2	1	1	2	1	2
3	5	3	4	3	1	4	1	4	2	3	1	1	1	3	2	3	4	3	2	4	3
4	2	1	3	2	2	1	3	3	2	3	2	1	3	3	2	3	2	2	3	2	2
5	3	3	3	2	3	3	3	3	2	4	3	2	1	2	2	2	1	2	3	3	4
6	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	2	1	1	1	1	3	1	1	1	1	1	1	1

'Friends' for "social" school

Ped	PRE- exer cise	PRE- exer cise	PRE- offer ed	PRE- offer ed	PRE- remi nder s	PRE- remi nder s	PRE- enco urag eme nt	PRE- sche dule	PRE- sche dule	PRE- disc uss	PRE- disc uss	PRE- com plain	PRE- critic ized	PRE- critic ized	PRE- rewa rds	PRE- rewa rds	PRE- plan ned	PRE- plan ned	PRE- help ed	PRE- help ed	PRE- ask plan	PRE- ask plan	PRE- talk	PRE- talk
1	3	3	2	2	3	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	2	3	1	2
2	4	4	2	1	3	1	1	3	1	1	4	1	1	1	1	1	2	2	1	1	2	4	3	5
3	3	3	2	4	4	4	2	5	3	3	3	4	1	1	1	3	4	1	3	3	3	2	4	2
4	3	3	3	3	1	2	2	2	1	1	2	3	1	1	1	3	4	2	2	4	1	2	2	1
5	4	4	4	3	1	3	0	0	1	1	2	4	4	1	1	4	5	4	1	2	3	2	4	1
6	3	3	4	4	2	3	3	2	3	3	2	2	1	1	2	2	4	2	5	3	3	3	4	3
7	2	1	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	3	2	1	1	4	4	1	1	1	1	1	3	2	1	1	2	1	2
9	1	3	1	1	1	3	1	3	1	1	1	2	1	1	2	1	2	1	1	1	2	1	2	3
10	5	5	4	5	4	4	1	4	2	2	3	3	2	1	1	1	1	3	1	1	4	2	2	4
11	1	1	3	1	3	5	3	4	2	2	3	3	4	1	2	1	1	2	3	1	2	3	2	2
12	3	3	4	3	5	1	4	5	4	5	4	4	2	1	1	3	2	4	3	4	4	2	3	3
13	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	3	1	2	2	5	1	5	2	3	3	2	1	1	1	3	4	1	1	3	1	1	1	1
15	4	4	3	2	1	2	2	3	2	4	2	2	3	1	5	3	4	3	3	3	2	4	5	1
16	2	2	3	2	1	3	3	2	1	1	4	4	3	5	1	1	2	3	2	4	5	3	1	2
17	2	1	1	2	1	3	2	2	1	1	2	4	1	1	1	1	3	3	1	2	2	2	3	2
18	4	5	4	5	3	4	3	5	3	2	4	5	3	4	4	3	2	4	3	3	4	3	5	1
19	3	4	3	2	2	3	4	3	3	4	3	1	4	2	4	1	3	3	1	2	1	2	5	2
20	4	4	4	3	2	4	5	5	4	2	5	3	1	4	4	4	3	3	2	5	4	4	3	5
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	2	1	2	2	1	1	3	2	2	1	3	4	1	1	4	1	2	1	1	1	2	1	2	2
23	4	4	3	2	2	2	2	2	3	2	1	2	4	2	2	3	4	1	2	2	2	3	2	4
24	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	3	3	2	3	2	2	3	2	2	2	2	2	1	2	1	2	1	2	1	3	3	3	2	3
26	3	2	4	3	2	1	1	1	5	1	2	2	4	1	4	2	1	2	3	3	3	2	1	4



## REFERENCES

- [1] BANDURA, A., “Self-efficacy: Toward a Unifying Theory of Behavioral Change,” *Psychological review*, vol. 84, no. 2, pp. 191–215, 1977.
- [2] BANDURA, A., “Health promotion by social cognitive means,” *Health education & behavior : the official publication of the Society for Public Health Education*, vol. 31, no. 2, pp. 143–164, 2004.
- [3] BANDURA, A., “Adolescent development from an agentic perspective,” *Self-efficacy beliefs of adolescents*, vol. 5, pp. 1–43, 2006.
- [4] BARANOWSKI, T., ABDELSAMAD, D., BARANOWSKI, J., O’CONNOR, T. M., THOMPSON, D., BARNETT, A., CERIN, E., and CHEN, T. A., “Impact of an Active Video Game on Healthy Children’s Physical Activity,” *Pediatrics*, vol. 129, pp. e636–e642, Mar. 2012.
- [5] BARANOWSKI, T. and JAGO, R., “Understanding the mechanisms of change in children’s physical activity programs,” *Exercise and sport sciences reviews*, vol. 33, no. 4, pp. 163–168, 2005.
- [6] BEGLEY, S., “A plunge in U.S. preschool obesity? Not so fast, experts say,” *Reuters*, Mar. 2014.
- [7] BERKOVSKY, S., FREYNE, J., COOMBE, M., BHANDARI, D., and BAGHAEI, N., “Physical activity motivating games: you can play, mate!,” in *OZCHI ’09: Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7*, ACM Request Permissions, Nov. 2009.
- [8] BERS, M. U., “Civic Identities, Online Technologies: From Designing Civics Curriculum to Supporting Civic Experiences,” *John D and Catherine T MacArthur Foundation Series on Digital Media and Learning*, pp. 139–159, 2008.
- [9] BOGOST, I., *Persuasive games: The expressive power of videogames*. Cambridge, Massachusetts: Mit Press, 2007.
- [10] BOYD, D. M., *Taken out of context: American teen sociality in networked publics*. PhD thesis, University of California, Berkeley, Oct. 2008.
- [11] BURKE, M., MARLOW, C., and LENTO, T., “Feed me: motivating newcomer contribution in social network sites,” in *Proceedings of the 27th international conference on Human factors in computing systems*, pp. 945–954, ACM, 2009.
- [12] BURKE, M., KRAUT, R., and MARLOW, C., “Social Capital on Facebook: Differentiating Uses and Users,” *CHI ’11*, 2011.

- [13] CAMACHO-MINANO, M. J., LAVOI, N. M., and BARR-ANDERSON, D. J., “Interventions to promote physical activity among young and adolescent girls: a systematic review,” *Health education research*, vol. 26, pp. 1025–1049, Nov. 2011.
- [14] CAPRIO, S., “Treating Child Obesity and Associated Medical Conditions,” *The Future of Children*, vol. 16, no. 1, pp. 209–224, 2006.
- [15] CARTER, S., MANKOFF, J., KLEMMER, S., and MATTHEWS, T., “Exiting the Cleanroom: On Ecological Validity and Ubiquitous Computing,” *Human-Computer Interaction*, vol. 23, no. 1, pp. 47–99, 2008.
- [16] CENTERS FOR DISEASE CONTROL AND PREVENTION, “About BMI for Children and Teens,” tech. rep., Centers for Disease Control and Prevention, Jan. 2012.
- [17] CLEMENT, A., “What Is Participatory Design?,” tech. rep., University of Toronto, Sept. 2012.
- [18] COHEN, S., UNDERWOOD, L., and GOTTLIEB, B. H., *Social Support Measurement and Intervention. A Guide for Health and Social Scientists*, Oxford University Press, 2000.
- [19] CONSOLVO, S., EVERITT, K., LANDAY, J. A., and SMITH, I., “Design requirements for technologies that encourage physical activity,” *Proc. CHI 2006*, p. 457, 2006.
- [20] CONSOLVO, S., McDONALD, D. W., and LANDAY, J. A., “Theory-driven design strategies for technologies that support behavior change in everyday life,” *Proc. CHI 2009*, pp. 405–504, 2009.
- [21] CONSOLVO, S., McDONALD, D., and TOSCO, T., “Activity sensing in the wild: a field trial of ubifit garden,” in *Proc. CHI 2008*, pp. 1797–1806, ACM Press, 2008.
- [22] DETERDING, S., “Gamification and its discontents,” in *Playful*, (London), Sept. 2010.
- [23] DETERDING, S., “Just add points?,” *UXCamp Europe*, May 2010.
- [24] DiSALVO, C., NOURBAKHSH, I., HOLSTIUS, D., AKIN, A., and LOUW, M., “The Neighborhood Networks project: a case study of critical engagement and creative expression through participatory design,” in *PDC '08: Proceedings of the Tenth Anniversary Conference on Participatory Design 2008*, Indiana University, Oct. 2008.
- [25] DRUIN, A., “The role of children in the design of new technology,” *Behaviour and Information Technology*, vol. 21, no. 1, pp. 1–25, 2002.
- [26] DUCHENEAUT, N., YEE, N., NICKELL, E., and MOORE, R. J., “‘Alone Together?’ Exploring the social dynamics of massively multiplayer online games,” In: *Proceedings of CHI 2006, ACM, New York*, pp. 407–416, 2006.
- [27] EBBELING, C. B., PAWLAK, D. B., and LUDWIG, D. S., “Childhood obesity: public-health crisis, common sense cure,” *Lancet*, vol. 360, no. 9331, pp. 473–482, 2002.

- [28] EIRIKSDOTTIR, E., KESTRANEK, D., MILLER, A. D., POOLE, E., XU, Y., CATRAMBONE, R., and MYNATT, E. D., “Stepping Outside the Classroom: Fitness Video Games For K-12 Settings,” *To be presented at the Workshop on Interactive Systems in Healthcare at the 28th international conference on Human factors in Computing Systems - CHI '10*, 2010.
- [29] EIRIKSDOTTIR, E., KESTRANEK, D., MILLER, A. D., POOLE, E. S., XU, Y., CATRAMBONE, R., and MYNATT, E., “Assessment of Health Games in Secondary Schools: An Investigation of the American Horsepower Challenge 2009-2010. Georgia Institute of Technology,” tech. rep., Georgia Institute of Technology, Atlanta, GA, USA, 2010.
- [30] FESTINGER, L., “A Theory of Social Comparison Processes,” *Human Relations*, vol. 7, pp. 117–140, May 1954.
- [31] FITBIT INC., “Fitbit,” *fitbit.com*, Nov. 2011.
- [32] GARZOTTO, F., “Broadening children’s involvement as design partners: from technology to,” in *IDC '08: Proceedings of the 7th international conference on Interaction design and children*, ACM Request Permissions, June 2008.
- [33] GLANZ, K., RIMER, B., and VISWANATH, K., *Health behavior and health education: theory, research, and practice*, vol. 30 of *Health Education Behavior*. San Francisco, CA: Jossey-Bass Inc Pub, 4th editio ed., 2008.
- [34] GRIESER, M., VU, M. B., and BEDIMO-RUNG, A. L., “Physical activity attitudes, preferences, and practices in African American, Hispanic, and Caucasian girls,” *Health education & ...*, 2006.
- [35] GRIMES, A. and GRINTER, R. E., “Designing persuasion: Health technology for low-income African American communities,” in *PERSUASIVE'07 Proceedings of the 2nd international conference on Persuasive technology*, p. 24, Springer, 2007.
- [36] GRINTER, R. E., SIEK, K. A., and GRIMES, A., “Is wellness informatics a field of human-centered health informatics?,” *Interactions*, vol. 17, p. 76, Jan. 2010.
- [37] HARDMAN, C. A., HORNE, P. J., and FERGUS LOWE, C., “Effects of rewards, peer-modelling and pedometer targets on children’s physical activity: A school-based intervention study,” *Psychology and Health*, vol. 26, no. 1, pp. 3–21, 2011.
- [38] HEALTH, DeKALB COUNTY BOARD OF, “2010 Status of Health in DeKalb Report,” tech. rep., DeKalb County Board of Health, Mar. 2010.
- [39] HUTCHINSON, H., MACKAY, W., WESTERLUND, B., BEDERSON, B. B., DRUIN, A., PLAISANT, C., BEAUDOUIN-LAFON, M., CONVERSY, S., EVANS, H., HANSEN, H., ROUSSEL, N., EIDERBÄCK, B., LINDQUIST, S., and SUNDBLAD, Y., “Technology probes: inspiring design for and with families,” *Proceedings of the*, 2003.

- [40] JAMNER, M. S., SPRUIJT-METZ, D., BASSIN, S., and COOPER, D. M., “A controlled evaluation of a school-based intervention to promote physical activity among sedentary adolescent females: project FAB,” *The Journal of Adolescent Health*, vol. 34, no. 4, pp. 279–289, 2004.
- [41] KAFAI, Y. B., HEETER, C., and DENNER, J., *Beyond Barbie and Mortal Kombat*. New Perspectives on Gender and Gaming, MIT Press (MA), Feb. 2011.
- [42] KELDER, S. H., PERRY, C. L., KLEPP, K.-I., and LYTLE, L. L., “Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors,” *American Journal of Public Health*, vol. 84, no. 7, pp. 1121–1126, 1994.
- [43] KENSING, F. and BLOMBERG, J., “Participatory design: Issues and concerns,” *Computer Supported Cooperative Work (CSCW)*, no. 1993, pp. 167–185, 1998.
- [44] KLASNJA, P., CONSOLVO, S., and PRATT, W., “How to evaluate technologies for health behavior change in HCI research,” in *CHI ’11: Proceedings of the 2011 annual conference on Human factors in computing systems*, ACM Request Permissions, May 2011.
- [45] KREBS, N. F., HIMES, J. H., JACOBSON, D., NICKLAS, T. A., GUILDAY, P., and STYNE, D., “Assessment of child and adolescent overweight and obesity,” *Pediatrics*, vol. 120 Suppl, pp. S193–228, 2007.
- [46] LENHART, A., MADDEN, M., SMITH, A., and MACGILL, A., “Teens and social media,” *Pew Internet and American Life Project*. Washington, DC, 2007.
- [47] LIN, J., MAMYKINA, L., LINDTNER, S., DELAJOUX, G., and STRUB, H., “Fish’n’Steps: encouraging physical activity with an interactive computer game,” *Lecture notes in computer science*, vol. 4206, pp. 261–278, 2006.
- [48] LUBANS, D. R., MORGAN, P. J., and TUDOR-LOCKE, C., “A systematic review of studies using pedometers to promote physical activity among youth,” *Preventive medicine*, vol. 48, no. 4, pp. 307–315, 2009.
- [49] MACKAY, A. and DURAN, C., “Adolescent Health in the United States, 2007,” *Centers for Disease Control and Prevention*, p. 150, 2008.
- [50] MACVEAN, A. and ROBERTSON, J., “Understanding exergame users’ physical activity, motivation and behavior over time,” in *CHI ’13: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1251–1260, ACM, 2013.
- [51] MAITLAND, J., CHALMERS, M., and SIEK, K. A., “Persuasion not required Improving our understanding of the sociotechnical context of dietary behavioural change,” in *Pervasive Computing Technologies for Healthcare, 2009. PervasiveHealth 2009. 3rd International Conference on*, pp. 1–8, 2009.

- [52] MAMYKINA, L., MYNATT, E., DAVIDSON, P., and GREENBLATT, D., “MAHI: investigation of social scaffolding for reflective thinking in diabetes management,” in *Proc. CHI 2008*, pp. 477–486, 2008.
- [53] MAMYKINA, L., MILLER, A., MYNATT, E. D., and GREENBLATT, D., “Constructing Identities through Storytelling in Diabetes Management,” in *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, pp. 1–10, 2010.
- [54] MARSHALL, S. J., GORELY, T., and BIDDLE, S. J. H., “A descriptive epidemiology of screen-based media use in youth: A review and critique,” *Journal of adolescence*, vol. 29, no. 3, pp. 333–349, 2006.
- [55] McALISTER, A. L., PERRY, C. L., and PARCEL, G. S., “How Individuals, Environments and Health Behaviors Interact: Social Cognitive Theory,” in *Health behavior and health education: theory, research, and practice*, San Francisco, CA: Jossey-Bass Inc Pub, 2008.
- [56] MILLER, A., PATER, J., and MYNATT, E., “Design strategies for youth-focused pervasive social health games,” in *Pervasive Computing Technologies for Healthcare (PervasiveHealth)*, 2013 7th International Conference on, pp. 9–16, 2013.
- [57] MILLER, A. D. and MYNATT, E. D., “StepStream: A School-based Pervasive Social Fitness System for Everyday Adolescent Health,” *CHI 2014*, Apr. 2014.
- [58] MILLER, A. D., POOLE, E., XU, Y., EIRIKSDOTTIR, E., KESTRANEK, D., CATRAMBONE, R., and MYNATT, E., “The work of play: supporting a pervasive health behavior change intervention for us middle school students,” *CSCW '12: Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, Feb. 2012.
- [59] MUELLER, F., AGAMANOLIS, S., and PICARD, R., “Exertion interfaces: sports over a distance for social bonding and fun,” in *In Proceedings of the ACM Conference on Human Factors in Computing (CHI '03)*, Fort Lauderdale, FL, Apr, pp. 561–568, ACM, 2003.
- [60] NORMAN, G. J., SCHMID, B. A., SALLIS, J. F., CALFAS, K. J., and PATRICK, K., “Psychosocial and environmental correlates of adolescent sedentary behaviors,” *Pediatrics*, vol. 116, no. 4, pp. 908–916, 2005.
- [61] OGDEN, C. L., CARROLL, M. D., KIT, B. K., and FLEGAL, K. M., “Prevalence of Childhood and Adult Obesity in the United States, 2011-2012,” *JAMA*, vol. 311, p. 806, Feb. 2014.
- [62] PARKER, A., KANTROO, V., LEE, H. R., OSORNIO, M., SHARMA, M., and GRINTER, R., “Health promotion as activism: building community capacity to effect social change,” in *CHI '12: Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems*, ACM Request Permissions, May 2012.

- [63] PEW INTERNET PROJECT, “Parent/Teen Digital Citizenship Survey,” tech. rep., Pew Internet Project, July 2011.
- [64] PHIPPS, S. A., BURTON, P. S., OSBERG, L. S., and LETHBRIDGE, L. N., “Poverty and the extent of child obesity in Canada, Norway and the United States,” *obesity reviews*, vol. 7, no. 1, pp. 5–12, 2006.
- [65] POOLE, E. S., EIRIKSDOTTIR, E., MILLER, A. D., XU, Y., CATRAMBONE, R., and MYNATT, E. D., “Designing for Spectators and Coaches: Social Support in Pervasive Health Games for Youth,” in *7th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth 2013)*, pp. 1–8, July 2013.
- [66] POOLE, E. S., MILLER, A. D., XU, Y., EIRIKSDOTTIR, E., CATRAMBONE, R., and MYNATT, E. D., “The Place for Ubiquitous Computing in Schools : Lessons Learned from a School-Based Intervention for Youth Physical Activity,” *Proceedings of the 13th ACM international conference on Ubiquitous Computing - Ubicomp '11*, pp. 395–404, 2011.
- [67] PROCHASKA, J. and PROCHASKA, J., “Why don’t continents move? Why don’t people change?,” *Journal of Psychotherapy Integration*, vol. 9, no. 1, pp. 83–102, 1999.
- [68] REDDING, C., ROSSI, J., ROSSI, S., VELICER, W. F., and PROCHASKA, J., “Health behavior models,” *The International Electronic Journal of Health Education*, vol. 3, pp. 180–193, 2000.
- [69] RIMAL, R. N. and REAL, K., “Perceived risk and efficacy beliefs as motivators of change,” *Human Communication Research*, vol. 29, no. 3, pp. 370–399, 2003.
- [70] ROBERTS, C. K. and BARNARD, R. J., “Effects of exercise and diet on chronic disease,” *Journal of applied physiology (Bethesda, Md. : 1985)*, vol. 98, no. 1, pp. 3–30, 2005.
- [71] ROSENKRANZ, R. R., BEHRENS, T. K., and DZEWALTOWSKI, D. A., “A group-randomized controlled trial for health promotion in Girl Scouts: Healthier Troops in a SNAP (Scouting Nutrition & Activity Program),” *BMC public health*, vol. 10, no. 1, p. 81, 2010.
- [72] ROTWEIN-PIVNICK, R., “Getting Kids And Adolescents Excited About Exercise,” *IDEA Fitness Journal*, vol. 3, no. 2, 2006.
- [73] ROWE, D. A., MAHAR, M. T., RAEDEKE, T. D., and LORE, J., “Measuring physical activity in children with pedometers: Reliability, reactivity, and replacement of missing data,” *Pediatric Exercise Science*, vol. 16, no. 4, pp. 343–354, 2004.
- [74] SAELENS, B. E., SALLIS, J. F., BLACK, J. B., and CHEN, D., “Neighborhood-based differences in physical activity: an environment scale evaluation,” *American Journal of Public Health*, vol. 93, no. 9, pp. 1552–1558, 2003.

- [75] SALLIS, J. F., PROCHASKA, J. J., and TAYLOR, W. C., “A review of correlates of physical activity of children and adolescents,” *Medicine and science in sports and exercise*, vol. 32, no. 5, pp. 963–975, 2000.
- [76] SALLIS, J. E. and GLANZ, K., “The Role of Built Environments in Physical Activity, Eating, and Obesity in Childhood,” *The Future of Children*, vol. 16, no. 1, pp. 89–108, 2006.
- [77] SALLIS, P., “SPARK Surveys.” University of California, San Diego, May 2013.
- [78] SCHELL, J., *The Art of Game Design: A book of lenses*. CRC Press, Aug. 2008.
- [79] SCHUNK, D. H., “Peer Models and Children’s Behavioral Change,” *Review of Educational Research*, vol. 57, no. 2, p. 149, 1987.
- [80] SKINNER, A. C., STEINER, M. J., and PERRIN, E. M., “Self-Reported Energy Intake by Age in Overweight and Healthy-Weight Children in NHANES, 2001-2008,” *Pediatrics*, Sept. 2012.
- [81] STAIANO, A. E., ABRAHAM, A. A., and CALVERT, S. L., “Competitive versus cooperative exergame play for African American adolescents’ executive function skills: Short-term effects in a long-term training intervention,” *Developmental psychology*, vol. 48, no. 2, pp. 337–342, 2012.
- [82] STORY, M., KAPHINGST, K. M., and FRENCH, S., “The Role of Child Care Settings in Obesity Prevention,” *The Future of Children*, vol. 16, no. 1, pp. 143–168, 2006.
- [83] TAVERNISE, S., “Obesity Rate for Young Children Plummets 43Decade,” *The New York Times*, Feb. 2014.
- [84] TOSCO, T., FABER, A., AN, S., and GANDHI, M., “Chick clique: persuasive technology to motivate teenage girls to exercise,” in *CHI’06 extended abstracts on Human factors in computing systems*, pp. 1873–1878, ACM, 2006.
- [85] TOSCO, T., FABER, A., CONNELLY, K., and UPOMA, A., “Encouraging physical activity in teens Can technology help reduce barriers to physical activity in adolescent girls?,” in *Pervasive Computing Technologies for Healthcare, 2008. PervasiveHealth 2008. Second International Conference on*, pp. 218–221, 2008.
- [86] WANG, Y., BEYDOUN, M. A., LIANG, L., CABALLERO, B., and KUMANYIKA, S. K., “Will all Americans become overweight or obese? estimating the progression and cost of the US obesity epidemic,” *Obesity (Silver Spring, Md.)*, vol. 16, no. 10, pp. 2323–2330, 2008.
- [87] WATSON, A., BICKMORE, T., CANGE, A., KULSHRESHTHA, A., and KVEDAR, J., “An Internet-Based Virtual Coach to Promote Physical Activity Adherence in Overweight Adults: Randomized Controlled Trial,” *Journal of Medical Internet Research*, vol. 14, no. 1, p. e1, 2012.

- [88] XU, Y., POOLE, E. S., MILLER, A. D., EIRIKSDOTTIR, E., KESTRANEK, D., CATRAMBONE, R., and MYNATT, E. D., “This is not a one-horse race: understanding player types in multiplayer pervasive health games for youth,” in *CSCW '12: Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, ACM Request Permissions, Feb. 2012.
- [89] YARDI, S. and BRUCKMAN, A., “Income, race, and class: exploring socioeconomic differences in family technology use,” *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems*, pp. 3041–3050, 2012.
- [90] YAROSH, S., RADU, I., HUNTER, S., and ROSENBAUM, E., “Examining values: an analysis of nine years of IDC research,” in *Proceedings of the 10th International Conference on Interaction Design and Children*, pp. 136–144, ACM, 2011.
- [91] ZIMMERMAN, B. and CLEARY, T., “Adolescents’ development of personal agency: The role of self-efficacy beliefs and self-regulatory skill,” *Self-efficacy beliefs of adolescents*, pp. 45–69, 2006.